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IMMENSITY AND MINUTENESS.*

J. E. GORE, F. R. A. S.

FOR POPULAR ASTRONOMY.

We are accustomed to consider the numbers dealt with in Astronomy as vast and wonderful. And so they are. Even the nearest fixed star to the Earth is placed at a distance so great that it seems impossible for the mind to grasp its reality. The distance of the Sun is very great when compared with the terrestrial distances with which we are familiar, and when we try to imagine that the distance of α Centauri—the nearest of the stars—is 271,000 times the Sun's distance from the Earth, our mind fails to grasp the idea of so vast a distance. The only way in which we can hope to gain even a faint idea of this vast distance is to consider the time that light takes to reach us from the nearest star. Coming from the Sun in about 8¼ minutes, light takes about 4⅓ years to reach us from α Centauri. And if this is the nearest of the stars how can we attempt to imagine the distance of the farthest star visible in the largest telescopes!

But these marvels revealed to us by the telescope are perhaps not more wonderful than the facts disclosed by the microscope and those inferred by physicists with reference to the constitution of matter. According to the molecular theory of matter all bodies—solid, liquid and gaseous—are composed of an enormous number of molecules, all vibrating round a mean position. Some have disputed this hypothesis and contend that matter may possibly be homogeneous and continuous and not composed of molecules or atoms, but Cauchy has shown mathematically that if matter were homogeneous and not molecular there would be no dispersion of light through a glass prism. The existence, therefore, of the science of spectrum analysis seems to prove conclusively that glass at least is molecular in structure. And yet the molecules of which it is composed are quite beyond the reach of our most powerful microscopes. "Fine rulings on glass whose distance apart is less than half of the wave-length are readily resolved with optical distinctness by our modern microscopes,

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while the intimate texture of the glass is apparently as far removed from resolution as with the unarmed eye." Professor Tyndall considered that the world of molecules and atoms lies "in all probability vastly farther beyond the range of the microscope than the range of the microscope at its maximum lies beyond that of the unaided eye." This is like the close binary stars recently discovered by the spectroscope some of which are probably as far beyond the reach of our largest telescopes as an ordinary telescopic double star is beyond the reach of the naked eye. This marvellous minuteness of the molecules of matter seems as difficult to imagine as the vast distances of the stars.

Cauchy concluded from optical experiments that the constituent atoms of matter are so small that 400 millions in a line would go to an inch. Clausius and Clark Maxwell found 500 millions from considerations of gaseous phenomena. From electrical experiments, Sir William Thomson (now Lord Kelvin) found 700 millions to the inch. Perhaps we may assume as a mean of these results that 500 millions of atoms placed in a straight line would measure an inch. These atoms are of course quite beyond the power of our microscopes, as I have said, but let us consider some living organisms which can be seen with the microscope. Certain forms of infusoria are so minute that an individual specimen can lie between two divisions of an inch divided into 25,000 parts! Now taking the height of a man at 6 feet or 2 yards, a length of an inch would be for this microscopical creature equivalent to a distance of 50,000 yards, or about 28 miles for a human being, and to such an animalcule a globe of 23½ feet in diameter would be as large in proportion to its own size as the whole Earth is to us! What would then represent the distance of the Sun and of the nearest fixed star to such a creature? Taking the Sun's distance as 92,800,000 miles it would be represented by 3,270,000 inches or over 51 miles, and the distance of the nearest fixed star by about fourteen millions of miles! So that for even these microscopic quantities the proportional distances of the stars would still be represented by enormous numbers.

For an atom of matter of the five hundred millionth of an inch in diameter, one inch would represent about 568,000 miles for a human being, or more than double the distance of the Moon from the Earth; so that on this scale the Sun's distance would be represented by 164 inches, or 13 ft. 8 in., and the distance of the nearest star by about 700 miles! Now 700 miles is 1/340th of the Moon's distance from the Earth. Perhaps the farthest

visible star is not more than 340 times the distance of α Centauri. If this be so, we may say that the diameter of the sphere containing the Earth and Moon—the Earth's system as it may be called—bears the same proportion to the diameter of the ultimate atom of matter that the diametr of the visible universe does to the height of a man. Although man's physical stature is of course very minute compared with the extent of the visible universe, the ultimate atom of matter is equally minute when compared with the diameter of the lunar orbit. According to Dr. Johnstone Stoney the number of atoms contained in a cubic millimeter of solids and liquids is something like 10^{21}, that is, 1 followed by 21 ciphers! How many atoms are contained in the Earth's mass? I leave this calculation to my readers.

THE BRIGHTNESS OF STARLIGHT.

J. E. GORE, F. R. A. S.

FOR POPULAR ASTRONOMY.

With reference to my paper on this subject in *Knowledge* for August 1901 (reprinted in POPULAR ASTRONOMY for Nov. 1901) another method has occurred to me of computing the value of starlight in terms of moonlight. If we assume that a star has the same diameter and intrinsic brilliancy as the Sun, we can, if we know the star's parallax, calculate its apparent diameter as seen from the Earth, and hence its brightness in terms of sunlight

Let p = Parallax of star.
D = Star's distance from the Earth.
R = Radius of Earth's orbit.
d = Diameter of the Sun.
A = Angular unit (206265″).

Then $$\mathrm{D} = \frac{\mathrm{AR}}{p}$$

Let α = angular diameter of star in seconds of arc

Then $$\alpha : \mathrm{A} :: d : \mathrm{D}$$

and $$\therefore \alpha = \frac{\mathrm{A}d}{\mathrm{D}} = \frac{pd}{\mathrm{R}}$$

Taking d = 866,000 miles and R = 93,000,000 miles we have

$$\alpha = \frac{866{,}000d}{93{,}000{,}000} = \frac{p}{107}$$

Now taking the total number of the visible stars at one hun-

dred millions, and assuming them to be equally distributed through a sphere whose radius corresponds to a parallax of 0″.001, as Professor Newcomb supposes, or a radius of 1,000 R where R is the distance of a star with parallax of 1 second, and further, supposing this sphere divided up into 10 concentric spheres, we have the following table:

Radius of Sphere	Volume of Sphere	Value of Shell	No. of Stars in Shell N	Parallax Aver.	$a = \frac{p}{107}$	Light $= Na^2$
100R	1,000,000R³	1,000,000R³	100,000	$\frac{1''}{50}$	$\frac{1}{5350}$	0.00349
200R	8,000,000R³	7,000,000R³	700,000	$\frac{1''}{150}$	$\frac{1}{16,050}$	0.00272
300R	27,000,000R³	19,000,000R³	1,900,000	$\frac{1''}{250}$	$\frac{1}{26,750}$	0.00265
400R	64,000,000R³	37,000,000R³	3,700,000	$\frac{1''}{350}$	$\frac{1}{37,450}$	0.00263
500R	125,000,000R³	61,000,000R³	6,100,000	$\frac{1''}{450}$	$\frac{1}{48,150}$	0.00263
600R	216,000,000R³	91,000,000R³	9,100,000	$\frac{1''}{550}$	$\frac{1}{58,850}$	0.00263
700R	343,000,000R³	127,000,000R³	12,700,000	$\frac{1''}{650}$	$\frac{1}{69,550}$	0.00262
800R	512,000,000R³	169,000,000R³	16,900,000	$\frac{1''}{750}$	$\frac{1}{80,250}$	0.00262
900R	729,000,000R³	217,000,000R³	21,700,000	$\frac{1''}{850}$	$\frac{1}{90,950}$	0.00262
1000R	1,000,000,000R³	271,000,000R³	27,100,000	$\frac{1''}{950}$	$\frac{1}{101,650}$	0.00262
			Total 100,000,000			0.02723

I have shown elsewhere that Sirius is about ten times brighter than it would be had it the same density and intrinsic brightness of surface as our Sun has. Now, supposing that about half the total number of stars have spectra of the Sirian type,* if we multiply the last two numbers in the last column of the above table by 10 they become 0.0262, and the total light is then 0.07439.

* This assumption may not be far from the truth, as most of the small stars in the Milky Way seem to have spectra of the Sirian type.

Taking the Sun's exponent diameter = 1920″ we have

Sunlight : starlight :: $(1920)^2$: 0.07439

or Sunlight : starlight :: 3,686,400 : 0.07439

Hence Sunlight = 49,555,047 × starlight

But Sunlight = 618,000 × Moonlight

and $\therefore$ 49,555,047 × starlight = 618,000 × moonlight

Hence $$\text{Starlight} = \frac{618{,}000}{49{,}555{,}047} \times \text{moonlight}$$

or $$\text{Starlight} = \frac{1}{80} \times \text{moonlight}$$

which is the same result as before. The data assumed in the above calculation are of course very uncertain, but perhaps not more so than the figures assumed in my previous paper for the value of sunlight in terms of the light of a star of zero magnitude.

DUBLIN, 1902, March 12.

THE CHINESE CALENDAR.

WILLIAM L. HORNSBY, S. J.

FOR POPULAR ASTRONOMY.

The regulation of the calendar has ever been an object of the greatest solicitude to the rulers of China. In their classic of history, which is perhaps the oldest piece of literature existing in any language, the very first records are concerned with the calendar. The first chapter of that classic is called "The Records of Yao." Yao is the first ruler of the nation, for whose existence and deeds we have solid historical testimony, and the date of his reign, which was one of patriarchal duration, is put between the years 2357 and 2255 B. C. Before Yao's time history is lost in mythology, and accordingly Confucius, in drawing up the canon of the classics, judiciously went back no farther than that period; reliable documents were wanting for more ancient times. The fact that there should have been at that early date—an antidiluvian date according to the Vulgate chronology—an established government, a people that could look back upon at least a century of national existence, was somewhat disconcerting at first for the early Jesuit missionaries. They were reassured, however, by hearing from Rome that the Septuagint chronology might be admitted, and that that the ancient date claimed by the Chinese for their patriarchal Emperor was in no wise contrary to certain data of Holy Writ.

It may be remarked in passing, that critics, both Chinese and foreign, are for the most part in accord as to the authenticity and the substantial veracity of the Chinese classics, as arranged —edited we might say—and transmitted by Confucius. Some have thought it possible that much of what passes for ancient literature never was seen by the sage; that it was forged some six centuries after his time, during the Han dynasty, B. C. 206—A. D. 220, a period of enthusiastic revival of literature. This hypothesis, however, is generally conceded to lack historical confirmation; on the contrary, many sufficiently convincing proofs, both intrinsic and extrinsic, are alleged for the authenticity of the ancient classics.

Astronomy makes its appearance in the third paragraph of the Records of Yao. The first paragraph recounts briefly the patriarch's virtues, and the second eulogizes the excellence of his rule. The third reads as follows; (the quaint old language is worth quoting literally): "Now he bade Hi and Ho reverently to regard the wide heavens; to calculate and observe the Sun, the Moon, the stars, the signs, and respectfully give the times of men. He separately bade Hi-chung to take up his station in Yu-i, called the *Valley of Light*, to welcome the rising Sun and equally order the affairs of spring. The day midway, and the *Bird* the star, will serve to divide midspring. The people disperse, and the birds and beasts come together and breed." Thus was the vernal equinox to be determined, and a similar order was given in the same picturesque language, to three others of the Hi and Ho families, who were to proceed one towards each of the other points of compass, to determine the autumnal equinox and the solstices. It will be gathered from the extract that the ancient emperor was more exact as an observer of nature, than versed in the science of astronomy. By the determining star, according to commentators, is meant the bright star that would appear near the meridian after sunset, and the *Bird* is explained to be our *Cor Hydræ*. It was so determined by a famous astronomer of the Tang dynasty (A. D. 618-907), who was acquainted with the phenomenon of precession, but it appears that he rather underestimated it. The corresponding stars for the other seasons were α Scorpii for the summer solstice, β Aquarii for the autumnal equinox, and the Pleiades for the winter solstice. Although this may not be quite exact, taking the date of Yao, as it is given, at 2300 B. C.; still it is sufficiently exact to corroborate roughly the high antiquity claimed for that emperor. That the stars mentioned in the old document were correctly identi-

fied by later astronomers, receives a confirmation from the name *Fire Star*, given to Antares, which is the same name that they give to the planet Mars. Thus the ancient Chinese did not fail to notice the relation of similarity between the planet and star, which the old Greeks expressed by the names *Ares* and *Antares*.

The text of the old document continues: "The Emperor said, 'Oh, you Hi and Ho! All around there are three hundred and sixty and six days; use the extra Moon, order the seasons and perfect the year. Faithfully regulate the hundred offices, and all the works will be great'." With this we have the simple principles of the Chinese calendar: the Sun was to be followed for the year, the Moon for the months, and the intercalation was to be so regulated as to keep the same Moons at the same periods of the solar year. The first care of Yao's successor upon taking over the government was to "examine the jeweled sphere and the tube of precious stones, for the ordering of the seven regulators,"—Sun, Moon and planets. Incidentally, we are presented with a pretty picture of that primitive civilization, eminently characteristic of the practical people that the Chinese are. They are not, indeed without their ancient poetry and myths, but it is extremely characteristic of them that their oldest and most revered piece of literature should be a simple record of how the ancient emperors busied themselves with such peaceful, practical questions as the calendar, agriculture, works of drainage, and the succession on the throne.

A century passes before any further mention of astronomy. We are then introduced again to Hi and Ho, the descendants, commentators say, as well as the successors in office of the astronomers of the earlier period. This time the narration is not so peaceful; it ends in a tragedy, and the chapter is entitled, as we must put it in our sophisticated language, "The Punitive Expedition of Yin." It reads as follows: "Hardly had Chung-kang begun to lord it over the four seas, when the Marquis of Yin was ordered to take command of the six legions. Hi and Ho had been wanting in their office, debauched with wine in their own town, and the Marquis of Yin received the Emperor's order to go and punish them." Then comes a long discourse of the Marquis to his troops, in which he sets forth the charge against the astronomers. "They had turned their conduct upside down," he says graphically, "sunk in wine and neglecting their duties. They have begun to go astray in their celestial calculations, and have put their office far away. At the dark of the Moon, the last of autumn, the heavenly bodies were not in accord in *Fang*

[the head of Scorpion]. The blind musician presented the drum; the higher officers came in haste, the lower officers ran. Hi and Ho were corpses in their offices, not knowing nor hearing, and so they have incurred the penalty of the ancient kings. The book of punishments says, 'who comes before the time, shall die: no pardon; who falls behind the time, shall die: no pardon'."

The court had been thrown into confusion and consternation, by the unexpected occurrence of an eclipse, and the prescribed ceremonies could not be performed with due decorum. To punish the offense of the delinquent astronomers, who were it appears hereditary princes, with cities and vassals of their own, the emperor was obliged to send against them a military expedition, commanded by the chief of his forces. So much to do over a matter relatively so trifling, and the intensely serious style of the narration, produce rather a ludicrous effect. But smile as we may, it must be admitted that the narrative brings out strongly the high value set upon astronomy among that primitive people; and that, not merely for superstitious reasons, as might appear from this single piece, but from the eminently reasonable conviction that astronomy is necessary for the regulation of the calendar, to determine "the times of men," as may be gathered from the earlier documents.

This famous eclipse, which must have been total or nearly so, has not been so easy to determine. It is described, however, rather circumstantially; occurring in the head of the Scorpion, between the dates Sept. 23rd and Oct. 21st, and visible at the capital of that time, long. 111° 5′ and lat. 35° 10′. The date adopted by the official history of China is that of 2155 B. C., which was determined by Anthony Gaubil, one of the Jesuit astronomers at Peking in the eighteenth century. The eclipse is said to have been examined again, and the date verified by Professor Russel, who was in Peking in 1894; the present writer has not had the occasion of learning the result of the investigation. The interest of the eclipse, in its bearing upon chronology, is evident.

Before leaving this ancient period, it may be of interest to mention that there are two stars in the Dragon, called respectively the *Heavenly Principle* and the *Great Principle*, which have been identified by Europeans as 10 Flamsteed, and 141 Piazzi respectively. The names are strikingly distinctive, and the present writer has in his notes, perhaps from Gaubil, that the *Heavenly Principle* was pole star in 2259 B. C., and the *Great Principle* in 2667. If the statement be exact, the fact would be

another confirmation of the authenticity and exactness of the ancient chronology. Gaubil argues similarly, that Chinese tradition cannot go back much further, as α Draconis has no such distinctive name. He puts the date when α Draconis might have been considered as the pole star, at 2851 B. C., and he concludes that these astronomical considerations would seem to show that the beginning of Chinese traditions should be placed between these two dates, that is, somewhere around 2700 B. C.

It is not the purpose of the present paper to trace the history of astronomy in China from the primitive beginnings just referred to. It will be enough to state that no progress was made in the science, and the calendar was generally not free from inexactitudes, until it was finally reformed by the Jesuits in the seventeenth century. Long before that date, the services of Mahometan astronomers had been availed of, but without eliminating disquieting errors. The accuracy of the Jesuits' calculations of eclipses and other phenomena, soon caused the entire direction of the bureau of astronomy to be confided to them. They were retained at the court as astronomers until the temporary suppression of the order in 1773, although after the death of the Emperor Kang-hi in 1722, the Christian religion was proscribed, and missionaries as such excluded from the empire. The first to suggest and introduce corrections was Fr. Adam Schall, a native of Cologne, who arrived at Peking in 1623. The calendar, however, as it still stands, was drawn up by Schall's successor, Fr. Ferdinand Verbiest, a Belgian. The latter was also the constructor of the fine old instruments, which were to be seen in the place where he erected them, on the wall of Peking, until they were removed during the troubles that followed the Boxer uprising in 1900. They were taken possession of by the Germans and what their final destination is to be seems to be still undecided, or at least not generally known.

Verbiest's reform of the calendar was published as a monumental work in thirty-two volumes, called after the celebrated Emperor then reigning, "The Kang-hi Perpetual Calendar." The special work covered several centuries, reaching down to the year yet to come A. D. 2020. By special work is meant all that is outside of general principles,—the calculation of the motions of the heavenly bodies and the times and phases of various phenomena. It went into great details, giving the phases of eclipses for instance, for fifteen provincial capitals. The official calendar for each year is published annually, in the eighth Moon of the preceding year, after receiving the Emperor's approval. Its prin-

cipal function is to mark the long and short Moons, the intercalations, when they occur, and the lunar dates of the solar stations. Eclipses are also noticed, with the times given for various provincial capitals. Local almanacs are published in some of the provincial capitals, and though they are filled with superstition, methods of divination and astrological notes, still they contain a certain amount of serious astronomical information of varied interest. Eclipses are noticed, but not always; sometimes space is needed for other matter. Last November, for instance, on the day of the solar eclipse, all the space was devoted to a notice in large heavy characters, that the day was lucky for calling in medical aid! There are rather notable errors, which if they exist in the original work of the Jesuit astronomer, may perhaps be accounted for by the inexactness of eclipse tables of that day, or by an imperfect knowledge of exact geographical positions. There are other errors, however, as in such a simple matter as the time of sunset, for instance, which would lead one to suppose that the data of our local astronomers are taken from some other source than the official calendar, or at least that they do not use intelligently the work of the learned Jesuit. The contents of a local almanac of Canton will be given as a curiosity at the end of this article.

The Jesuits made few changes in the calendar, so old and sacred in national tradition. They simply rectified errors, leaving the solar year with its divisions, and the lunar month, with the system of intercalation, just as they found them. They evidently sought to avoid changes that the people might notice. They divided the zodiac into 360°, instead of 365¼°, which was the old division, following the daily motion of the Sun. They introduced the twelve signs of western astronomy, for practical purposes, leaving for more popular use the twenty-eight irregular and unequal constellations, *stopping places*, into which the zodiac had been divided.

The calendar, as it exists today, is quite simple, but it possesses over our calendar, as some at least will say, the advantage of an interesting variety, arising from the combination of the solar and the lunar years. There are twenty-four solar stations, marking fixed epochs of the year, quite independently of the civil year, which follows the Moon. The solar stations are determined by the Sun passing the first point and the middle point of the twelve signs; that is, they occur at every fifteenth degree of the Sun's longitude, which is reckoned from the winter solstice. The first point of a sign, or 0°, is called a *Principal*

Station, and the middle point, or 15°, a *Division Station*. Each station has its proper name, of astronomical, meteorological or agricultural import. Eight of the names are purely astronomical, the equinoxes, the solstices, and the four points midway between these divisions. The meteorological names predominate, being thirteen in number, marking the time of intense and moderate heat and cold, of dew and snow, rain and fair weather. The meteorological indications are adapted to the northern provinces; the seasons of slight and intense cold, of light and heavy snows, have not much meaning for a Cantonese. In the north the changes of season are remarkably regular, and follow the calendar exactly enough. Only two of the stations have strictly agricultural names, and one, the *Awakening of Insects*, March 6th, is scarcely to be classified under any of the above heads.

The civil year begins with the first new Moon after the Sun enters Aquarius; or, more strictly, with the second Moon after the winter solstice. It is an inviolable rule that the winter solstice falls in the eleventh Moon, and as the winter lunations are long, when the solstice falls in the early hours of the first day of the Moon, the second Moon thereafter may begin after the Sun has passed into Pisces. That happened but twice during the century just elapsed, in the years 1833 and 1852. In the embolismic year, a thirteenth Moon is not added at the end, but one of the Moons is doubled. The rules for intercalation are simple, and may be reduced to just two. The first is the rule just referred to, that the winter solstice must be kept in the eleventh Moon. The reason for this rule is perhaps to be found in the fact, that the winter solstice is in their astronomy what the first point of Aries is for us; it is the starting point, and everything is to be regulated by it. The second rule of intercalation is that the extra Moon be so introduced as not to contain a principal solar station; that is, the Sun does not pass from one sign to another. A consequence of this rule is that the three mid-winter Moons, the 11th, 12th and 1st of their calendar, are never doubled, as at that season a lunation is longer than the time it takes the Sun to pass from one sign to another. In the cycle of the Golden Number, there are regularly seven embolismic years, corresponding to the numbers 1, 4, 7, 9, 12, 15, 18; but these years are departed from when adhering to them would throw the winter solstice out of the eleventh Moon.

By these simple rules of intercalation, a happy combination is effected between the solar and the lunar years, and the result is a calendar of fixed solar seasons on the one hand, and of a pleasing

variety in the civil year on the other. Their divisions of seasons and Moons follow the Sun and Moon, and are not so arbitrary as our months. The solar stations are regulated by the solstices and equinoxes, natural not arbitrary divisions, and their months follow the Moons. Though it may not recommend itself to practical people, there is something more attractive and interesting in saying, for instance, the third of the third Moon, than the third of an arbitrary division of the year called March. It is surprising at what an early age the little children begin to count by the days of the Moon. While our children content themselves mostly with the day of the week, the little Chinese boy, for whom there is no week, is early accustomed to count by the day of the Moon. Superstition comes in to help their education in learning the calendar. The first and the fifteenth of each Moon are days of special devotion; and others are scattered throughout the year at no great intervals. They have a fondness for dates in which the numbers are doubled, as the third of the third Moon, the fifth of the fifth. On such days of devotion, extra tapers and incense-sticks are burned before the household gods, and fire-crackers are set off, in quantities varying according to the solemnity of the feast and the devotion and means of the family. All of this must impress the childish imagination, and help the little ones at an early age to keep count of the days.

The Moons are divided between *great* moons and *little* ones; that is, of thirty and twenty-nine days respectively. The great moons predominate in the winter months, and the little moons in the summer months, owing to the difference in the periods of lunations. The calendar as drawn up in the time of Kang-hi gives the length of the moons for every year, but imperial command may change that disposition, irrespective of just where the Moon falls astronomically. Thus the twenty-first year of Quong-su, the reigning Emperor, 1895 of our era, was curtailed of a day on account of the humiliating treaty concluded with Japan in that year. The change meant simply putting a great moon at the beginning of one year, instead of at the end of the preceding year.

The Chinese have no seven-day week, but they have a similar convenient division in the three decades, upper, middle and lower, into which they divide the Moon. The Jesuit astronomers did not attempt to introduce the foreign week, though it is necessarily taught to Christian converts. Along the coast the Chinese can all count by the days of the week, and the *Day of Worship*, as Protestant missionaries have translated Sunday, is marked in

many of the Cantonese almanacs. Christians in the interior, provided with ecclesiastical calendars, also keep run of the week, but they use it only for religious purposes. So in the ports the natives keep to their own methods of counting time, except for dealings with foreigners. Many double calendars, giving the correspondence between the Chinese and European dates are published annually and most of the Cantonese almanacs give the corresponding European dates.

To conclude this little notice of the Chinese calendar, it may be of interest to give the contents of one of the more serious of our local popular almanacs of Canton. The specimen chosen was picked up the other day from the floor of a store-room of old books, where it was lying on a heap of rubbish. It proved to be an almanac of the nineteenth year of His Majesty Quong-su, and upon inquiry at the shops, it was found to be a very popular almanac, still published annually in exactly the same shape and form. The preface is dated 1862; it was composed by the compiler, a certain Cho King-yuen, native of a district near Canton. He states that his father had been very fond of astronomy, and had taught him the elements of the science in his early years, and that he had himself later devoted many years to the study. He apparently belongs to the well-to-do gentry class, which is rather numerous in this rich province, particularly in the vicinity of Canton, the most commercial city of China. He goes on to say that it had often caused him pain to see that the almanacs in popular use were so inaccurate as to the motions of the heavenly bodies, the consequence being that the good people were often led astray in their choice of lucky days! His own preface is preceded by a few remarks of a high mandarin, vice-president of one of the imperial boards of government and an academician. This worthy begins his remarks naturally with a reference to the Emperor Yao, and goes on to speak of the importance of astronomy for the right choice of lucky days! How different from the intention of the old patriarch, to whom he refers, who insisted only upon the necessity of regulating "the times of men." There is nothing superstitious or idolatrous in the oldest Chinese documents.

After the brief prefaces and a little chapter on the importance of exact divination, there follows a variety of information, mostly astronomical, which may be reduced to twenty-two heads.

1. Diagram of celestial and terrestrial spheres combined showing equator, ecliptic with 24 solar stations; but all confused, and apparently adapted to the old Ptolemaic system.

2. Chart of northern heavens, showing the 28 zodiacal constellations near horizon. No regard is had for the configuration of the constellations, which should not be recognized without the names.

3. Latitude of 19 provincial capitals and of eight prefectural cities of the province of Canton. The latitude is given under an astronomical heading, as the altitude of the pole for the different places.

4. Longitude and latitude of 94 zodiacal stars; longitude reckoned on ecliptic from winter solstice. The table is preceded by a notice of precession, the annual change given correctly at 51″. The Jesuit astronomers introduced the division of degrees, and of hours as well, into 60 minutes, and of minutes into 60 seconds. The Chinese had formerly followed the decimal system.

5. A table arranged for the benefit of night-watchmen, giving the bright stars near the meridian at the different watches of the night, for the twenty-four solar seasons. The night is divided into five watches, which are beaten with from one to five strokes, according to the number of the watch, on a resonant bamboo tambour. Evidently the watchmen are supposed to know the constellations!

6. Relative brilliancy of Seven Regulators (Sun, Moon and five planets) and fixed stars. Not at all clear: the writer prefers to think that he does not understand it, than to admit in the almanac such errors as that of making the Sun only a few degrees brighter than the Moon, and putting Mercury above Venus! A native astronomer might give the table some reasonable explanation.

7. A table for telling the time of day by the shadow of a foot-rule, for the twenty-four seasons. An intelligent remark is made at the beginning, to the effect that, whereas in China there are foot-rules of various lengths, it matters not which one be used, provided the shadow be measured by the same standard.

8. Difference of time of the Sun's passing the 24 stations for 17 provincial capitals. This, it is evident, is the same as giving the longitude of the different cities in time, east or west of Peking, which is taken as 0°. Incidentally, this table and that of the latitudes bring out the geographical importance of the country: a solid empire with provincial capitals ranging between latitudes 23° 11′ and 41° 52′ and a difference of nearly an hour and a half in time from east to west, is no small affair, even apart from the consideration of China's productiveness and the density of her population.

9. Sunset and sunrise at Canton for every two days. Quite correct for apparent time: mean time does not seem to be used at all.

10. Distance in degrees of arc of rising and setting Sun from east and west points, calculated quite correctly for latitude of Canton.

11. Table for finding twenty-four houses of the Sun (astrological), at any hour of the day, for the 24 seasons.

12. Adjustable diagram for finding houses of Moon and planets at any given time. Rather ingenious.

13. Declination of ecliptic at 24 solar stations.

14. Correspondence of 28 zodiacal constellations with the signs: they are extremely irregular, varying from 1° to 30° in extent.

15. The stars of different provinces. They seem to be assigned arbitrarily, without regard apparently for correspondence of latitude and declination.

16. Daily motion of the Seven Regulators and the *Four Extras*, and their respective periods. Roughly correct, but not at all exact: the daily motion and period of the two inferior planets are both given as identical with those of the Sun. Exact information is given in the Ephemeris, No. 22. Of the four *Extras*, two are easily identified as the nodes of the Moon, but the other two are not so easy to recognize.

17. A little discussion of the different use of the terms "Five Agents." They are water, fire, gold, (or metal in general), wood, earth, and they correspond to the four elements of western philosophy of other days. The planets are called after the Five Agents: Mercury is the Water Star, Venus the Gold Star, Mars the Fire Star, Jupiter the Wood Star, Saturn the Earth Star. Uranus and Neptune have not the honor of being recognized by purely native astronomers: they are duly noticed, of course, in text-books published by foreigners.

18. About 60 pages devoted to methods of divination, astrology, palmistry, etc.

19. Times of the 24 solar stations for five southern capitals.

20. Ninety-eight pages devoted to the calendar proper. They are taken up largely with superstitious notes, giving auspicious times and days for even the most trifling affairs, as for shaving the head and having the cue dressed. Some almanacs under this section give more attractive notes, such as the time for the passage of certain birds, for the first song of others, for the blooming of different flowers, for thunder and lightning, and

when the rainbow may begin to appear. If the birds, flowers and elements should not keep their appointments, so much the worse for them: that is no fault of the calendar-maker. The times of the Moon's phases and the 24 solar stations are given to the minute, but with a limit of error of nearly half an hour! It must be said, however, to the credit of our Cantonese astronomers, that the errors may be largely due to the printer. Chinese know what good printing is: but in such popular books the print is very bad, quite illegible in places and never reliable.

21. Diagram showing time of planets entering the twelve signs.

22. Ephemeris of the Seven Regulators and the Four Extras. Only the longitude is given, counted by degrees of the 28 zodiacal constellations. It is remarkably accurate, and the way it is given would seem to show that it is taken from a purely native or at least from no modern western source.

Thus ends the almanac published by the "Hall for Honoring the Sun." With all its follies and its occasional inaccuracies, we must certainly confess that it contains a rather surprising amount of accurate information as coming from no professional, but, as it appears, from a person of retired leisure, who inherited his father's taste for astronomy.

MACAO, Feb. 2, 1902.

AN ECLIPSE CYCLE.

W. H. S. MONCK.

FOR POPULAR ASTRONOMY.

In looking over some eclipse records (though I suspect that calculation as well as observation enters into a good many of the dates given) a cycle occurred to me which I do not recollect to have seen before, viz., 521 years. It is, of course, too long to be very convenient in use but sub-periods may perhaps be found to simplify this. (I took the dates from Mr. Johnson's treatise generally stopping at 1752 because the change in the English Calendar in that year introduced some confusion). This cycle was suggested to me by the dates of the eclipses recorded by Ptolemy in the Almagest, in which I found a total eclipse on March 19 B. C. 721 in the afternoon and another on the same day in B. C. 200 also in the afternoon, while the fact that Ptolemy recorded both shows that the places at which they were visible were not very far distant. I did not trace this particular eclipse

farther, but the records are scanty; and I may add that, as the number of days in 521 years is not always the same, the date of the eclipse indicated by the cycle may be varied by a day or two.

On Jan. 24, 1023 there was a large eclipse at London. On the same day in 1544 a total eclipse is recorded by Tycho Brahe, which must have been seen at no great distance from the former.

In the year A. D. 17 there was an eclipse of the Sun total at Rome on the 15th of February. On the same day in 538 an eclipse was seen in England and recorded in the Saxon Chronicle.

Here is a series of lunar eclipses in the month of March. On March 2d A. D. 462 a lunar eclipse was visible at Rome. There is no note in the work before me, of its appearance on its next return but a second application of the cycle brings me to the eclipse of Columbus March 1st, 1504. And in the table of future eclipses (here the intercalary days come in) I find that on March 14, 2025 the Moon will set in eclipse in London.

In April I find an eclipse of the Sun on April 30th B. C. 403 alluded to by Eusebius. On the 30th of April A. D. 59 there was a large solar eclipse at Rome mentioned by Pliny and Tacitus.

In May, the eclipse which is usually (though doubtfully) supposed to be that of Thales, took place, May 28 B. C. 585. The next return is not noted in the volume before me, but on May 28 A. D. 458 an eclipse of the Sun was noted by Idatius, and though I do not meet with the subsequent appearances I find one calculated for June 10, 2021 (the intercalary days apparently explaining the difference). Again, on May 1st, 664, an eclipse of the Sun was visible in England and recorded in the Saxon Chronicle. On the same day in 1185 an eclipse of the Sun was also visible in England and probably the eclipse of the 12th of May 1706 belongs to the same series (the observer quoted was at Berne) and I find an English eclipse predicted for 15th May, 2227. (The cycle suits the old style better than the Gregorian correction).

In June I find an eclipse of the Sun observed at Alexandria on the 16th in A. D. 364; on the same day in 885 there was a conspicuous eclipse in Scotland recorded in the Chronicon Scotorum. On the same day in 1406 an eclipse was observed in England, while the largest English eclipse to which we are now looking forward will take place on June 29th, 1927. Another long-lived eclipse is first heard of in B. C. 661 as recorded in a Babylonish inscription when it occurred on June 27. I find it again on June 26, A. D. 1424 when it is visible in Europe, and there is to be an eclipse on July 9, 1945.

There are two July series nearly of the same date but distinct.

One began on July 19, B. C. 104 when there was an eclipse of the Sun at Rome mentioned by Julius Obsequeus. On the same day A. D. 418 an eclipse is recorded by Philostorgius. On the same day in 939 there was an eclipse in Spain: On July 18th, 1460 there was a great eclipse in Austria and the Turkish dominions and an eclipse is predicted for July 17th, 1981; but if this belongs to the same series we do not here experience the usual change of 12 days. The other series begins with an eclipse on 16th, 809 when an eclipse of the Sun is recorded in the Saxon Chronicle. On the same day in 1330 an eclipse was visible in Europe and the eclipse of July 28th, 1851 visible in the north of Europe seems to belong to the same series.

I would tire the reader if I continued this analysis further and in some instances (as already hinted) I am doubtful whether there is a real diversity in dates or only a question of intercalary days. I find an instance of this in the month of August. Thucydides refers to an eclipse of the Sun of August 3 B. C. 431. Passing over two returns which do not seem to have been recorded I obtain a well known eclipse of August 2 A. D. 1133 recorded in the Saxon Chronicle. But an eclipse was seen in the British Isles on August 12, 1654 and one is predicted for August 16, 2175. Do they belong to the same series or not?

No cycle will, of course, last forever, but this one in numerous instances gives several successive eclipses visible in the same locality.

SHADOWS CAST BY STARLIGHT.

HENRY NORRIS RUSSELL.

FOR POPULAR ASTRONOMY.

It has long been known that Venus casts a distinct shadow; and the same thing has sometimes been observed in Jupiter's case. More recently, it has been stated in the daily press* that shadows cast by Sirius have been seen at the Harvard Observatory in Jamaica, though it was then said that they could probably be seen only where the air is exceptionally clear.

The writer began to investigate this subject, quite independently, last November, and has found that the shadows cast by a number of the brighter fixed stars can be seen without difficulty under ordinary circumstances, provided proper precautions are taken to exclude extraneous light, and to secure the maximum sensitiveness of the observer's eyes.

* Interview with Professor W. H. Pickering, *New York Tribune*, Jan. 18, 1902.

The most convenient method of observation is as follows: Choose a window from which the star is visible, while as little light as possible enters from terrestrial sources. Darken the room completely, with the exception of this window. Open the window, and screen down its aperture to an area of a square foot or less. Hold a large piece of white paper in the path of the star's rays, as far from the opening as possible. The image of the opening will then appear on the paper.

It cannot, however, be well seen until the observer has spent at least ten minutes in the dark, (to rest his eyes from the glare of ordinary lights). The paper should be held within a foot or so of the eyes, as the faint patch of starlight is most easily visible when its apparent area is large. The shadow of any convenient object may now be made to fall on the screen, and may be observed. By holding the object near the window and noticing that its shadow is still sharp, the observer may convince himself that the light which casts the shadow really comes from the star.

By the method above described, the writer has succeeded in distinguishing shadows cast by the following stars, (which are here arranged in order of brightness):

	Mag.		Mag.
α Canis Majoris (Sirius)	−1.4	ζ Orionis	1.9
α Boötis (Arcturus)	0.0	β Tauri	1.9
α Aurigae (Capella)	0.2	γ Geminorum	2.0
β Orionis (Rigel)	0.3	β Canis Majoris	2.0
α Canis Minoris (Procyon)	0.5	α Hydrae	2.0
α Orionis* (Betelgeuse)	0.8?	α Arietis	2.0
α Tauri (Aldebaran)	1.0	κ Orionis	2.2
β Geminorum (Pollux)	1.1	β Leonis	2.2
α Virginis (Spica)	1.2	γ Leonis	2.2
α Leonis (Regulus)	1.4	δ Orionis	2.4
ε Canis Majoris	1.5	η Canis Majoris	2.4
α Geminorum (Castor)	1.6	ζ Argus	2.5
ε Orionis	1.8	α Ceti	2.7
δ Canis Majoris	1.9	15 Argus	2.9
γ Orionis	1.9		

The groups of stars comprised in the Pleiades and the sword of Orion also cast perceptible shadows. With a wide-open window the belt of Orion should be added to this class.

Most of the observations on which this list is based were made at Princeton on February 7th, and 8th, and March 6th, 1902. The first of these nights is recorded as not remarkably clear, the others as very clear. Whenever there was any doubt of the reality of an observed patch of starlight, it was located at least three times, and it was verified each time that the star was really visi-

* Variable.

ble from the spot where its light had been located. Many more stars might have been added to the 29 in the foregoing list, had not unfriendly street lamps confined the observations to less than half the sky.

As many of the stars observed were at a low altitude, it may be concluded that a star of the 3d magnitude, if near the zenith, would cast a perceptible shadow.

In attempting to get a shadow from these faint stars, the opening of the window should be narrowed to a width of a few inches, so as to cut off as much as possible of the diffused light of the sky. Care should be taken not to look at the sky while observing, as it is bright enough to dazzle the eyes for some little time.

By observing these precautions, the writer has been able to detect shadows cast by Sirius, Arcturus and Capella on moonlight nights,—in the case of Sirius, even when the Moon shone into the room.

The actual brightness of the screen, even when illuminated by Sirius, is very small in comparison with that of the "dark" background of the sky, as seen by the naked eye. White paper reflects about 80 per cent of the incident light. From photometric considerations, a disk of this material 1° in apparent diameter, illuminated perpendicularly by Sirius, should send us about 1/16,000 as much light as the star.

But, according to Professor Newcomb's determination*, an area of sky 1° in diameter, remote from the Milky Way, sends us 9/10 as much light as a 5th magnitude star, or about 1/400 of the light of Sirius. Hence the sky is about 40 times as bright, area for area, as the paper illuminated by Sirius.

The illumination of the paper by a 1st magnitude star is about 1/400 as bright, and by a 3d magnitude star less than 1/2000 as bright, area for area, as the "dark" background of the sky.

This faint light, as might be anticipated, shows no perceptible color. The light of the white stars β and γ Orionis and the red star α Orionis does not differ sensibly in quality; but the light of the red star appears much fainter than the star's brightness, as directly seen, would lead one to anticipate. On the screen, the light of α Orionis is much fainter than that of β, and only a little brighter than that of γ, while by direct vision α is much nearer to β than to γ in brightness. As β is 1½ magnitudes brighter than γ, it appears that, as measured by the intensity of its light on a

* *Astrophysical Journal* December 1901.

screen, α Orionis is at least half a magnitude, perhaps a whole magnitude, fainter than when compared with the neighboring white stars by direct vision.

Such a result might have been anticipated *à priori*, since, in the case of such faint lights as are here dealt with, the eye is sensitive to the green part of the spectrum alone, and this is relatively brighter in the spectrum of a white star than of a red one.

A much more interesting example of the accordance of theoretical prediction with observation is afforded by another phenomenon discovered by the writer, which is not hard to observe.

A surface illuminated by a planet—Venus for example—appears uniformly and evenly bright, but in the case of a fixed star, there are marked variations in brightness, so that the screen appears covered with moving dark markings.

This was predicted many years ago by Professor Young, in discussing the twinkling of the stars. He says*: "If the light of a star were strong enough, a white surface illuminated by it would look like the sandy bottom of a shallow, rippling pool of water illuminated by sunlight, with light and dark mottlings which move with the ripples on the surface. So, as we look toward the star, and the mottlings due to the irregularities of the air move by us, we see the star alternately bright and faint; in other words, it twinkles."

It would be difficult to give a better description of the observed phenomenon than the one contained in the first part of the above quotation. It need only be added that the dark markings are much more conspicuous than the bright ones. This agrees with the fact that a star more frequently seems to lose light while twinkling than to gain it.

Sirius is the only star whose light is bright enough to make these light and dark mottlings visible without great difficulty, though the writer has seen them in the light of Rigel and Procyon. With Sirius they have been seen every time the star's light has been observed on a moonless night. They are much more conspicuous when the star is twinkling violently than on nights when the air is steady.

In the latter case there are only faint irregular mottlings, whose motion produces a flickering effect. More usually there appear also ill-defined dark bands, two or three inches wide. These are never quite straight nor parallel but usually show a preference for one or two directions, sometimes dividing the

* *General Astronomy*, page 538 (edition of 1898).

screen into irregular polygons. On some nights they merely seem to oscillate, but on others they have a progressive motion, which may be at any angle with their own direction. The rate of motion is very variable, but is greatest on windy nights,—another evidence of the atmospheric origin of the bands.

The best nights for observing these bands occur when the stars are twinkling strongly, and there is not much wind. The directions given above for observing shadows should be somewhat modified in this case.

If the room is not at the same temperature as the outer air, the window should be kept closed, as otherwise most of what is seen will be due to the air-currents near it. It is also desirable to have an area of star-light at least a foot square to see the bands in, so that a good sized part of the window should be left clear.

If Sirius is unavailable, Arcturus and Vega are probably the best stars in whose light to attempt to see the bands.

PRINCETON, N. J., March 24, 1902.

SEARCHING FOR NEW STARS.*

DR. T. D. ANDERSON.

"And must I ravel out my weaved-up"—"follies," I was about to say, like King Richard; but since nothing astronomical could possibly be called foolish, I shall alter Shakespeare and say "my weaved-up past?" Of course I am reluctant; but your request is a sufficient excuse for any apparent lack of modesty on my part.

I need hardly say that before the advent of Nova Aurigæ my astronomizings were fruitless—fruitless, that is to say, so far as the rest of humanity was concerned, but far from being fruitless as regarded myself, for there was for me at least a certain joyful calm when, after a long evening spent in writing sermons or in other work, I threw up the window and taking out my little pocket telescope surveyed the never palling glory of the midnight sky. But after the appearance of Nova Aurigæ, the thought occurred to me that perhaps after all new stars might not be such rare phenomena as had up to that time been supposed. The correctness of that surmise has been proved by Mrs. Fleming's discovery since then of no fewer than five of these objects on the Harvard College photographs, although it is certainly strange that all these Novæ should have appeared in the Southern Hem-

* This paper is a letter written by Dr. Anderson of Edinburgh, Scotland, Feb. 19, 1892, to H. B. Hollis, editor of *The Observatory* and published in that journal in March of this year. His discoveries of variables make an important list.

isphere. I therefore resolved to commence a search for new stars, a resolve in which I was encouraged by Professor Copeland, the Astronomer Royal for Scotland, who gave me advice as to instruments, charts, catalogues, etc., and told me that my search, if unsuccessful so far as Novæ were concerned, would almost certainly lead to some discovery or other.

Accordingly I at once purchased a large binocular. This I soon reinforced by a second-hand 2¼-inch refractor by the well-known Jesse Ramsden, which shows me stars down to the tenth magnitude; but desiring to see still fainter objects, I bought in 1899 a 3-inch refractor by Mr. William Hume of this city. With this last instrument I can on a clear night see stars as faint as the eleventh magnitude. As regards charts I was somewhat unfortunate, for I had the mortification of learning, when I sent to Bonn for those of the B.D., that many of them were out of print. However, I secured the whole of them for the sky north of + 40° and I filled up the lacunæ among those for the more southerly regions by means of some constructed by myself with the help of the positions given in the B.D. Verzeichniss. These home-made charts, containing as they do, upwards of 70,000 stars, cost me a deal of time. It was a work which I should scarcely have undertaken had I known that a new edition of the B.D. charts would appear in a few years. In the matter of catalogues, too, I was somewhat unsuccessful, since all my efforts failed to obtain for me that part of the B.D. Verzeichniss which contains the stars north of + 41°. Still, as I had the charts for that part of the sky, the want of the 'Verzeichniss' was little felt by me, and I subsequently supplied any deficiency in that reepect by purchasing the various volumes of the great Gesellschaft Catalogue as they came out.

Thus armed I began to hunt for new stars. I worked with might and main, never going to rest as long as the sky remained clear, and often rising in the night to see if the clouds had passed away, and if they had, hurrying down stairs to begin work either with binocular or with telescope. The chief obstacle that I have had to contend with in such work is that the only windows in this house from which I can thoroughly examine the heavens face the northwest. Not only is my field of labor thereby very greatly circumscribed, my telescope being able to command only that part of the heavens which extends from the equator to + 70°, but the discomfort is frequently not inconsiderable, as the northerly and northwesterly winds which so often bring with them transparent, unclouded skies, are in winter and early spring far

from being balmy, and can make themselves felt even when the window-shutters are partially closed.

At first my search was mainly for Novæ and was prosecuted by means of my binocular, but after several months passed in diligently comparing the heavens with my charts, I found nothing that could be mistaken for a Novæ except the 8th magnitude star Weisse-Bessel XIX^{h} 358 (otherwise 4767 of the First Glasgow Catalogue), which through some oversight is omitted from the first edition of the B.D. charts. As this star lies in the constellation Aquila between the two branches of the Milky Way, I pounced on it at once as a Nova, only to find to my disgust that it was a well-known and long-established denizen of the firmament. (This star has, I may mention, been inserted in its proper place in the new edition of the B.D. charts). When I came to see that hunting for Novæ was not attended by the success which I had anticipated, I began, without entirely abandoning such work, to make a systematic search for variable stars. For this I used my 2¼ inch telescope, comparing what it showed me with the representation of the heavens contained in the B.D. charts. Of course there were very many discrepancies between the two, for it must be remembered that Drs. Argelander, Schönfeld, and Krueger, when making the B.D., never intended that it should be complete except for stars of the ninth magnitude and brighter. Of fainter objects—and, as those who use the B.D. know, these form a large proportion of the stars laid down—there is only a selection. In many instances stars little brighter than the tenth magnitude have been inserted, while others nearly of the ninth magnitude have been omitted. It can easily be imagined how puzzling this was to me, especially as it was to a large extent faint stars that I examined for variability. I was always glad if, after three or four months of searching, during which I might have examined perhaps 20,000 stars and suspected fifty or sixty of variability, I was able at last to come across one whose brightness changed.

I found Nova Persei, I need hardly say, without either binocular or telescope, when I was casting a casual glance round the heavens.

I enclose a list of the variables discovered by me (p. 249). The positions are taken from Dr. Hartwig's Ephemerides for this year, except in the case of the three unnamed ones, *i. e.*, the three last found. Two of these three are B.D. stars, and their places are taken from that work. The place of the third one,—Ophiuchi, is the same as that which I have given in *A. N.* 3731. The aver-

age magnitudes at maximum are mainly from my own knowledge of the past history of these variables.

I have perhaps been too diffuse in answering your queries, but possibly something that I have written may be of use to you in one way or another.

	Name.	R.A. 1855.0. h	m	s	North Decl. 1855.0. °	′	Mag. at Max.	Variability announced.
1	X Andromedae.....	0	8	30	46	12	8½	1900
2	T Andromedae.....	0	14	50	26	11.4	8	1893
3	V Andromedae.....	0	42	13	34	51.8	8½	1896
4	RR Andromedae....	0	43	30	33	35	9¼	1901
5	U Andromedae.....	1	7	14	39	57.0	9½	1895
6	Y Andromedae.....	1	31	8	38	36.3	9½	1900
7	W Andromedae.....	2	8	25	43	37.8	7	1899
8	Z Tauri.....	5	44	6	15	45	9	1900
9	X Aurigae.....	6	0	54	50	14	8½	1900
10	S Lyncis.....	6	32	3	58	2.7	9½	1897
11	X Geminorum.....	6	37	50	30	25.2	8	1897
12	V Ursae Majoris....	8	57	54	51	42	9½	1901
13	T Canum Venat.....	12	23	1	32	18.3	8½	1897
14	RU Herculis.....	16	4	10	25	27.1	7½	1896
15	— Herculis.....	16	25	50	7	8.9	9	1901
16	RV Herculis.....	16	55	2	31	26.4	9½	1897
17	RT Herculis.....	17	4	58	27	14.3	9	1896
18	RS Herculis.....	17	15	38	23	3.9	8	1895
19	— Ophiuchi.....	17	49	39	11	11	9	1901
20	RY Herculis.....	17	53	28	19	29.7	9	1899
21	V Draconis.....	17	55	24	54	52.6	9	1900
22	W Lyrae.....	18	9	54	36	37.4	8	1896
23	V Lyrae.....	19	3	24	29	25.8	9½	1895
24	U Draconis.....	19	9	54	67	2.4	9	1897
25	TZ Cygni.....	19	12	12	49	55	9½	1901
26	RT Aquilae.....	19	31	10	11	23	9	1897
27	RV Aquilae.....	19	33	48	9	35.4	9	1900
28	RU Aquilae.....	20	5	56	12	33.8	8½	1898
29	SX Cygni	20	9	45	30	37.9	9	1899
30	X Delphini.....	20	48	13	17	5.6	8½	1895
31	R Equulei.....	21	6	15	12	12.4	8½	1900
32	X Pegasi.....	21	14	8	13	50.3	9	1898
33	— Pegasi.....	21	37	56	24	20.6	8½	1901
34	Y Pegasi.....	22	4	36	13	38	9½	1900
35	V Cassiop.....	23	5	27	58	53.8	8	1893
36	W Pegasi.....	23	12	34	25	29.1	8	1895
37	Z Cassiop.....	23	37	30	55	46.6	9½	1898
38	RR Cassiop.....	23	48	24	52	55	9½	1900

AURORAL PHENOMENA AT ALTA IOWA.

DAVID E. HADDEN.

FOR POPULAR ASTRONOMY.

About nine o'clock in the evening of March 29th, 1902 a bright auroral beam was observed in the southeast sky at an altitude of about 30 degrees.

When first seen it was more or less obscured by light clouds and its true nature was hard to determine. It was a perpendicular, pale narrow streak of light, about 5 degrees in length

and about one-half degree in width, with the star γ in the constellation Virgo, almost exactly in the middle of the beam. About 20 minutes later the clouds cleared away and the beam was a beautiful object, resembling strongly a fine comet of a pale greenish-white light, ten minutes later it reached its maximum brightness when it was a deep yellow to orange color and had moved about a degree farther north. Underneath, towards the horizon was a dark region, above which was a faint auroral glow. Five minutes later the phenomenon disappeared and did not appear again.

Its position in the southeast quadrant of the sky was unusual, and many people supposed the light to be a comet.

It is a noteworthy coincidence that a large bright region of faculæ was observed nearly at the east limb of the Sun in north heliographic latitude 30 degrees, the following day.

During the past twelve years a large number of auroras have been observed and studied at this station, and during the years of increased sunspot activity, the frequency and brilliancy of the auroral displays were much augmented.

In looking over my observing note book I found a number of instances where auroral beams with little or no motion were observed, and as such phenomena have been often mistaken for comets by the public and amateurs, a short account of those I observed may be of interest.

On the night of July 13th, 1892 following a brilliant display of Northern Lights, a superb beam of greenish light resembling a long narrow fish was visible from Coma Berenices to Leo Major and remained stationary until it gradually faded out.

July 16, 1892, a beam of light spread athwart the sky from northwest to southeast which was nearly stationary.

On July 15th, 1893 a bright beam of light stretching from the northwest sky to Lyra near the zenith, was supposed at the time by many newspapers and some astronomers to be some remarkable change in comet *b* which was discovered about a week previously, and was receiving much attention by the press and public.

On the night of May 3rd, 1899 a fine comet-like beam of light was observed in the northwest sky at an altitude of about 18 degrees, this resembled very much the photographs of Brooks' comet of 1893.

June 28th, 1899 bright comet-like beams of light were visible in the northeast sky at a height of about 45 degrees, later, swiftly moving parallel bars were observed near the same region.

On January 20th, 1900 following a slight auroral display in the northern sky, a fine, bright beam of light extended horizontally from the west to south horizon at a height of about 18 or 20 degrees.

In nearly all the above cases Northern Lights either preceded or followed the beam phenomena, but in the case of the streak seen recently, no disturbance was at any time to be seen in the northern sky at this station.

In *Monthly Notices*, Vol. 56 for March 1896, Professor H. H. Turner, Sir W. J. Herschel, W. H. Robinson and others call attention to a curious light seen in England on March 4th of that year, which they supposed to be the zodiacal light, probably owing to its position in the western sky, and the direction of the streak which, if prolonged, would pass through the Pleiades.

In *Knowledge* for April and May 1896, a number of correspondents also refer to the same phenomenon, and variously ascribe it to the zodiacal light, a meteor track or Sun pillar. There is no doubt in my mind from the descriptions given and the behavior of the light that it was one of the numerous manifestations of the aurora.

In *Nature* for March 28th, 1896 Dr. Brauner, of Prague, calls attention to luminous streaks observed by him on the 13th of the same month, and under the heading "Some Luminous Appearances in the Sky" in *Publications of the Astronomical Society of the Pacific*, Vol. IX, No. 54, W. H. S. Monck gives an account of a number of instances in which similar streaks of light were reported by various observers, and were mistaken for comets, meteors, etc., and which the author does not feel satisfied were auroral.

In looking over the U. S. Monthly Weather Review for March 1896, I find that the dates on which the number of reports of auroras especially exceeded the average were March 4th, 6th, 11th, 13th, and 14 and this would seem to indicate conclusively that the lights were auroral in character and that while the displays were typical Northern Lights over wide areas, in other places, probably dependent on local conditions, peculiarities in the shape of streaks and beams of light prevailed.

The subject is interesting and worthy of careful observation and study on the part of amateur and professional astronomers and meteorologists.

ALTA, Iowa, April 7th, 1902.

THE STELLAR FLOOR.

EDGAR L. LARKIN.

FOR POPULAR ASTRONOMY.

The stellar floor is surely visible from the Lowe Observatory.* It is the background of the universe or that part of it within range of telescopes—that glimmer or phosphoresence shining beyond the separate stars. The entire sidereal structure is draped in white, but the cloth of pearl is rent and torn in thousands of places. These apparent openings or rifts are dark, or in some cases apparently black. The robe of nature is not nebula, being unlike that sheen round about Orion, for where the real cosmical floor is on display the nebulosity is absent. The azoic pavement, basic rocks of stars, apppears to be made up of inconceivable multitudes of minute stellar points. The sidereal sheet is granular, and the granules are as fine as those seen on a gelatine-bromide plate. When first seen here it was thought a mistake had been made, so nothing has been printed until now after more than a year of careful scrutiny, through all possible changes of weather and varying conditions of air. In the darkest mountain-night, extensive areas of the celestial vault are almost solid white, yet made up of microscopic points.

Positively this is not due to diffused light in the atmosphere of the Earth. for other parts are dark, or seemingly black, on the same night. Thus, on last night, Feb. 28th, 1902, after a three days' rain, the primordial stellar floor was seen in more wonderful display than during the past year. The dust from the Mojave desert was absent and the mountain air was of such absolute purity that the air on plains even, cannot be compared with it. The floor below the stars ranges through all degrees of intensity from pure white easily seen down through faintest shimmer and sheen to the limits of visibility.

So many nebulæ are seen here that no attempt is made to form a catalogue—this can be so much better done by observatories having photographic outfits. The question of differences of eyes is involved. The writer always thought the Merope nebula could be seen by all observers, until informed by those having long experience that it could not. It is easily seen here and in fact all the bright stars in the Pleiades are surrounded by nebu-

* For views of Lowe Observatory and its beautiful surroundings see POPULAR ASTRONOMY No. 87.

losity, while the Hyades are not, but the stellar floor is observed on almost all sides of this V shaped group.

The writer has often thought that his eyes were "corrected" for the wave-lengths active in photography, for it is easy to see a faint nebula, and difficult to detect the minute component of a large double, especially if they differ much in color. No lines curved or straight can be seen on Mars at favorable oppositions, while the larger colored areas are dim. The minute double star a^2 Capricornus is seen without difficulty, because they are of the same color, faint and equal. Until coming to this summit it was thought that the dark space following the trapezium in the Orion Nebula was black even up almost to the trapezium. But from this mountain Observatory a wide faint nebulous bridge across the chasm is seen following, and two wisps of nebula parallel to the length of the rift, at right angles to the bridge and following.

The trapezium with its well known six stars is an easy object, but there are two stars preceding and one south, which form the extreme limit of vision. The great nebula is flocculent in the entire central region, while the immense area beyond in all directions, even to the end of the sword is composed of streamers, and tufts, the whole presenting an aspect differing in many ways from the object as seen in lower altitudes.

Exquisite Areas in the Stellar Floor.

R. A.		Decl.		R. A.		Decl.	
h	m	°	′	h	m	°	′
2	50	9	20	23	55	56	
3	20	38	30	22		38	40
2	30	−18	50	21	45	45	30
				21		−26	

Next to the last in the list is remarkable for it is a case where the stellar floor and a dark space are seen in the same field, clear cut and distinct. The sidereal sheet is beautiful and perfect round about A Pegasi, and in the central square of Orion. But four-fifths of Orion is in front of a nebulous curtain. It is simply enshrouded in nebula.

Starless Fields—Approximate Centers.

R. A.		Decl.		R. A.		Decl.	
h	m	°	′	h	m	°	′
16	50	−22	20	18	10	−20	
17	25	−26	35	18	10	−18	25
18		−18	50	18	13	−18	1
18	3	− 4		5	42	− 8	20

The last in the table is in Orion, for almost everything can be found in this constellation. The starless fields are not black,

neither is the rift in the Orion nebula—that which seems so is contrast. There is light in space and it does not suffer extinction to the amount usually supposed. The universe is also doubtless far larger and more massive than commonly believed.

It is of incredible antiquity, and cosmical evolution is in great activity at present. The eyepiece used was Gundlach's periscopic, flat field, diameter 37′ 30″, with the most exquisite definition. A curious nebula is seen at

R. A.		Decl.			R. A.		Decl.		
h	m	°	′		h	m	°	′	
20	55	31	30	North end.	20	50	30	30	South end.

That is 1° in length, irregular, with tufted boundaries. Altitude of Observatory is 3420 feet.

LOWE OBSERVATORY, March 1, '02.

REVIEW OF SOLAR OBSERVATIONS FOR THE YEAR 1900, AT ALTA, IA.

DAVID E. HADDEN.

FOR POPULAR ASTRONOMY.

The following solar observations are in continuation of those published in POPULAR ASTRONOMY for April 1900. Only a brief resumè is given in these notes, the detailed daily observations have been furnished regularly for several years to the solar section of the British Astronomical Association. The instrument used was a four inch refractor by Brashear.

January 1900.—The disc was free from spots during the first decade, occasional small spots appeared during the remainder of the month and a fair-sized group was at the east limb on the 26th which completed the transit of the disc by February 7th.

February.—In addition to the January group referred to above a large scattered group of spots was near the east limb in north latitude on 4th, which, two days later, formed a train of spots, but shortly afterwards diminished, reaching the west limb on the 15th as a minute spot. The disc was free from spots during the remainder of the month.

March.—A large and interesting group was visible between the 6th and 11th, when it disappeared by solar rotation. It probably appeared suddenly near the central meridian sometime between the 2d and 6th while observations were interrupted by cloudy weather. The group underwent many remarkable

changes from day to day, and on the 7th reversals of the Hydrogen lines were noticed in the region between the large spots. This group re-appeared at the eastern limb on the 25th much diminished in size, and completed the transit of the disc, mainly as a single large spot, disappearing on April 7th. This region of the solar surface—a little south of the equator—was again the location of another fine group which appeared about April 26th at the east limb, and developed into a very extended stream containing some large areas of penumbræ with many nuclei, which was highly interesting during its entire transit until disappearance about May 7th.

April.—With the exception of the large spot during the early part of the month, and its reappearance on 26th at east limb, already mentioned, the disc was disturbed with only small groups of spots which were of no particular interest.

May.—The opening of the month found the extended stream of spots already mentioned under March, nearing the central meridian, the disturbed region was manifested by three large penumbral patches, each of which contained many small nuclei; Aurora was also coincident with the group's presence on evening of April 30th. Few, or no spots were present until about the 16th when the telescope was dismounted for shipment to Wadesboro, N. C. to observe the total eclipse on the 28th.

June.—The disc was spotless during nearly the first half of the month. On the 14th small spots were at the east limb, near equator, north, which, in a couple of days had greatly increased in size and made the entire transit of the disc. Other small spots of the 18th also completed the transit.

July.—The first half of this month was generally spotless. From the 17th until near the closing days of the month, a few medium-sized spots were present.

August.—With exception of minute dots from the 7th to 14th, and on 29th and 30th, the disc was spotless during the month of August.

September.—Mainly small and scattered spots were on the Sun between the 1st and 12th after which date the disc was spotless during the balance of the month.

October. With the exception of a small group which appeared on the 7th near the central meridian and increased as it neared the west limb, the Sun's surface was generally clear until the middle of the month.

On the 16th a large-sized group came into view by solar rotation in southern latitude near the equator, which later developed

into an extended stream of many small spots; later, a large double leader spot formed and was interesting during its passage across the disc, and disappearance on the 28th.

November.—This month was mainly spotless; but a couple of pores being visible during the month.

December.—The tranquility of the Sun's surface noted in November, continued undisturbed by a single spot during this entire month.

The following table exhibits the numerical results of the observations for the year:

Months—1900.	Number of Observation Days.	Average Number of			Average Number of Groups	
		Groups.	Spots.	Faculæ.	N. Latitude	S. Latitude.
January	21	0.71	2.52	1.25	0.43	0.28
February	13	0.92	5.23	0.66	0.61	0.31
March	23	0.61	2.00	1.00	0.17	0.43
April	21	1.47	7.00	1.67	0.76	0.71
May	15	0.86	5.73	1.33	0.40	0.46
June	27	0.81	4.50	0.90	0.40	0.41
July	27	0.64	2.64	1.14	0.25	0.40
August	28	0.36	1.64	0.57	0.00	0.36
September	24	0.83	3.10	0.80	0.00	0.83
October	23	0.80	6.00	1.00	0.00	0.80
November	17	0.30	0.60	0.60	0.00	0.30
December	16	0.00	0.00	0.80	0.00	0.00

Compared with the preceding year, there has been a slight diminution in the average number of groups, spots and faculæ during the year 1900. The number of spotless days has increased from 108 in 1899 to 134 in 1900.

In the subjoined table is given the annual average results for the years 1891 to 1900, inclusive:

Years.	Number of Days of Observation.	Average Annual Number of			Total No. of Spotless Days.
		Groups.	Spots.	Faculæ.	
1891	257	2.9	14.9	3.6	24
1892	205	5.6	34.0	4.1	0
1893	177	6.6	36.6	4.1	0
1894	139	5.6	30.0	3.4	0
1895	149	5.2	30.5	3.5	0
1896	197	3.2	17.8	2.9	5
1897	198	2.2	11.0	2.3	29
1898	234	2.1	11.0	2.4	30
1899	259	1.1	4.8	1.5	108
1900	255	0.7	3.4	1.0	134

The total number of spotless days for the past year, 1901, was 212 out of 269 observing days, or about 79 per cent, compared with 52½ per cent in year 1900.

Complete results for 1901 will be published soon.

ALTA, Iowa, April 4th, 1902.

THE LIGHT CURVE OF THE NEW STAR IN PERSEUS.

CONTINUED FROM PAGE 206.

Date 1901.	Gr. M. T.	Comparisons.	Magnitude. Obs'r.	Magnitude. Revised.	Color
April	h				
28	7.4	$v + 1.17$	5.20	5.10	Y
30	7.4	$v + 1.62$	5.65	5.55	YR
May					
1	7.4	$v + 2.00$	6.03	5.93	YR
2	7.4	$v + 0.77$	4.80	4.70	YR
3	7.4	$v + 2.20$	6.23	6.13	R

During the remainder of May and June no observations are recorded but a good series extends from July 14 to Oct. 5.

DISCUSSION OF THE LIGHT CURVE.

From the two Plates (XV POPULAR ASTRONOMY, Nov. 1901 and XII, May 1902) it will be seen that the curve for the first four months is very irregular and evidently follows no single law. The steepness of the rise on Feb. 21 is vouched for by the fact that on Feb. 19 and 20 photographs of the region of the Nova show no trace of a star in its place. On Feb. 19 a photograph was taken at Harvard College Observatory with an exposure of 66^m, beginning at $11^h\ 18^m$ Gr. M. T., which shows stars of the 11th magnitude but not the Nova. On Feb. 20, the day before the discovery by Mr. Anderson, a photograph taken by Mr. A. Stanley Williams, at Hove, England, exposed from $10^h\ 47^m$ to $11^h\ 27^m$ Gr. M. T., shows stars of the twelfth magnitude but no trace of the Nova (*M. N.* LXI p. 337). It is clear thus that the accession of light was extremely rapid, and that within the interval of 28 hours, at most, the brightness increased nine and one-half magnitudes.

There is one observation recorded which would tend to show that the rise of the star was even more rapid, and that the star was brighter a few hours before than at the time of discovery by Mr. Anderson. This was, however, made by an inexperienced observer and is negatived by two observers of greater experience.

Mr. Andreas Borisiak, at Kiew, Russia, records the star as 1.5^m Feb. 21 at $5^h.0$ Gr. M. T., nearly nine hours before Mr. Anderson records it as 2.7^m. Mr. Borisiak is a young student, 16 years of age at the time of the observation, who has a small telescope and studies the heavens every clear evening. It would seem that he might have been mistaken in the date of his observation and that it was really made on the night of Feb. 22, when it would accord well with other observations. Professor Glasenapp of St. Petersburg and Professor R. Vogel of Kiew, however, upon

investigating the matter, appear to be convinced that the observation was really made on Feb. 21, but that perhaps the brightness was estimated too high (*A. N.* 3700).

On the other hand, one and two hours later, two experienced variable star observers, Messrs. Schwab, of Ilmenau, and Plassmann, of Münster, state that they compared Algol with stars on both sides of the place of the Nova and did not see it. Mr. Schwab estimates that it could not then have been brighter than 4.5^m, and puts it at less than 5.0^m. Mr. Plassmann thinks that it was certainly below 3.0^m.

Another observation, recorded as having been made on Feb. 21, is worthy of note. This is by a student in the astronomical department of Vassar College, who says that at about 11^h P. M. (16^h Greenwich mean time) it was as bright as, if not brighter than, Capella (P. A. No. 84, Apr. 1901, p. 221). Here again I think those who examine the chart will agree with me that it is most probable that a mistake was made in the date and that the observation was made upon Feb. 22, when it would agree well with those of other observers. It is not safe, however, to state this as a positive conclusion. It may have been that the star rose to a sudden sharp maximum early in the evening of Feb. 21, and as suddenly declined, so that it was at a minimum at the time of the observations by Schwab and Plassmann, and that it was again rising at the time of discovery by Anderson and reached another maximum about an hour later, when the star was observed at Vassar College Observatory. The disposition of the platted observations on Feb. 22 may perhaps seem to corroborate this view, by indicating a steeper curve than the one drawn, as if there were a minimum early on the 22d. The data are insufficient to decide the question but on the whole I am inclined to regard the curve as indicating somewhere near the truth concerning the course of change in the star's light. In view of our later knowledge of the immense distance of the star it would seem that the catastrophe, whatever it may have been, which caused the outburst of light, was too tremendous for its effect to have perceptibly diminished in the first few hours. It is so easy to be mistaken in one's date, especially where the date is an afterthought instead of an immediate record, that the theory of such an error is easier to accept, than that such an enormous increase of light could be reversed in the course of an hour or two.

The maximum of brightness, as indicated by the curve, was reached about midnight on Feb. 23, and appears to have been very near 0.0 magnitude. The curve should perhaps have been

drawn a little lower, but I preferred to give greater weight to the two photometric observations and the eight statements that the star was brighter than Capella. The error can hardly be greater than 0.1 magnitude.

After the 23rd the curve descends quite steadily for nearly three weeks. There are some indications of small undulations having a possible period of about two days, but these are mostly lost sight of in the larger errors of observation. The one undulation indicated from Feb. 27 to Mar. 1 is pretty well determined and some of the others may have been of greater amplitude than is indicated by the curve.

It will be noticed that nearly all of the observations were made between the hours of 6 and 16 Greenwich mean time. A reliable series of estimates made in India or Japan would be of great service in establishing the character of the curve, but up to the present no observations from the other side of the globe have come to hand except the few rough estimates by Professor Nægamvala and a few observations made by Professor Nijland while on the 1901 eclipse expedition to Sumatra. There does not seem, however, to be much evidence of any fluctuations of less period than one day, so that probably the greater part of the curve as drawn is very nearly correct.

The slight maxima on March 12, 14 and 18, with the intervening minima, may be regarded as fairly well established. On Mar. 19 a remarkable diminution of the star's light occurred, the majority of the observers agreeing in recording the magnitude as from 1.0^m to 1.5^m lower than on the 18th. This would correspond to a loss of from three-fifths to three-fourths of the star's light, which took place in twenty-eight hours. During the next twenty-four hours the lost light was regained and perhaps a little augmented. At the time of the probable maximum on Mar. 20 no observations are recorded, so that its height is a little uncertain. On the 21st the steep descent of the curve is quite certain but the depth of the minimum is doubtful. The rapid rise on Mar. 22 is well established but the maximum is again uncertain. This part of the curve is suggestive of a rotating body bright on one side and dark or veiled in absorbing vapors on the other, or of two bodies revolving about each other, the one bright the other relatively dark. These hypotheses, however, are not sustained by other parts of the curve. The maximum on March 23 and 24 is drawn out to twice the length of that on the 20th, and the following minima, March 25 and 28, are longer and less deep than those on the 19th and 22nd, while that on the 31st is so short and shallow as to be quite uncertain.

On April 2 another decided minimum occurred, lasting for over two days, followed by a series of similar fluctuations, with short maxima and long minima, extending through the month of May. In all of these, where the observations are sufficient to determine the character of the curve, the rise is steeper than the descent. The heights of the maxima are nearly the same, allowing for a gradual diminution of the average light of the star, and up to May 12 they seem to have approximately the same form and duration. The minima are all long drawn out and, in general, increase in length up to May 13. After that time there is an appreciable decrease in their length, although the exact length in each case is quite uncertain.

The amplitude of the variation of the star in April is difficult to determine, because of the wide range of the estimates made by different observers at the same time, but it was probably about 1.5^m up to May 8 and after that gradually diminished. The minimum magnitude is less accurately shown than the maximum, the range of estimates being about a half magnitude greater for the former than for the latter. It is difficult to see why observers, inexperienced though some of these were, should differ so widely as a whole magnitude, when comparing stars of nearly equal brightness, but taking for example the three dates April 20, 21 and 22, where nearly all of the platted observations have been reduced to the same system, the estimates are pretty uniformly distributed from 5.2^m to 6.2^m and on the 21st the extreme range is 1.4^m. Strange to say, the photometric measures, of which there are six on each night, exhibit the same range of discrepancy. The only satisfactory explanation I can suggest is that the discrepancy is due to the different color perception of observers with different instrumental aid. The Nova at minimum was always of a deep red color, contrasting quite strongly with that of the comparison stars. To an eye sensitive to red, and upon a blue background such as that shown in an opera glass or telescope of very low power, a red star might appear relatively much brighter than a white or blue star of really equal brilliancy, while in a more powerful instrument which would give a black background and to an eye less sensitive to red the blue or white star might appear the brighter.

During the latter half of May and in June the position of the Nova was unfavorable for observation, being always seen at a low altitude, and the majority of the observers discontinued their watch of the star. A few, however, in northern latitudes kept up their observations, and we have a nearly complete series,

the most serious lack being on the dates May 29 and 31, June 11—12, 15, 16 and 26. Maxima were observed on May 13, 18, 22, 26, 30, June 3 and 8. There are indications of others June 11, 12, 22, 24 and July 4 but these are quite uncertain; the discrepancies would be scarcely larger than those in April if the curve were drawn without any undulations after June 10.

The observations on May 13, 14, 17 and 18 are curiously grouped, so that the curve drawn through the mean of the platted points satisfies scarcely any of the individual observations. There does not seem to be any sufficient reason, however, for discriminating between the two sets of points which lie above and below the curve.

The writer has collected the published observations from all accessible sources up to the present time, finding estimates made upon nearly every date from July 14 to November 21 and on about half the dates from that time to Feb. 10, 1902. In these later observations there are indications of only slight fluctuations of the star's light, so that it does not seem advisable to continue the platting of the curve further at present.

In drawing the curve no attempt has been made to equalize the periods between the maxima. In some cases this might be done without much apparent sacrifice of the accuracy of the observations, but in others it would be impossible, and it seemed best to draw the curve impartially through the mean of each group of platted points, without any preconceived theory as to its character.

The following table exhibits the irregularity in the intervals between successive maxima:

Maximum.		Interval.	Maximum.		Interval.	Maximum.		Interval.
Feb.	23.4		April	1.1		May	22.6	
		5.1			3.6			3.7?
	28.5			4.7			26.3?	
		2.0:			4.2			4.0?
Mar.	2.5			8.9			30.3	
		2.7:			4.0			4.5
	5.2			12.9		June	3.8	
		7.2:			5.2			4.7
	12.4			18.1			8.5	
		2.4			5.3			3.3?
	14.8			23.4			11.8?	
		3.2			3.8			...
	18.0			27.2			...	
		2.8			5.2			...
	20.8		May	2.4			22.2:	
		2.2:			4.9			2.5:
	23.0:			7.3			24.7:	
		3.9:			6.0			9.8:
	26.9			13.3		July	4.5:	
		3.4			4.7			
	30.3			18.0				
		1.8			4.6			

A large number of observations have come to hand since the first part of the curve was printed (Plate XV, POPULAR ASTRONOMY, No. 89, Nov. 1901), but these have indicated no material changes in its structure.

THE COLOR CHANGES.

Many of the estimates of the color of the Nova are quite inconsistent with each other, yet there is a general trend in the color estimates indicating similar fluctuations to those of the star's brightness. It is somewhat confusing to have seven observers in the course of two hours, as for instance Mar. 3, call the star in succession "reddish yellow," "red," "decided red," "orange," "white with perhaps a tinge of yellow," "reddish yellow," "reddish," but still by striking an average one may probably come somewhere near the true color of the star.

Mr. H. Osthoff, in *Astronomische Nachrichten* No. 3751, has attempted, by assigning numbers to the successive colors of the spectrum, to construct a color curve of the Nova and has succeeded in revealing in it a general resemblance to the light curve.

From the records given in this paper it appears that the color was at first bluish white, and that at the maximum on Feb. 23 it was almost pure white, although one calls it "bluer than α Lyræ," and another marks it "pale yellow." As the light faded the color shifted toward the red end of the spectrum, so that by March 1 it was designated by most observers as reddish or orange. This color continued until the great fluctuations began, after which, almost without exception, with each upward fluctuation of the light the color shifted toward the blue, becoming at the maxima either white or yellow or at least a lighter shade of red, while at the minima the color was almost uniformly nearer to the red, or a darker shade of red than at maxima. This is well shown in the following table, in which I have put, for each date of a maximum and for one of the dates of each intervening minimum, what seems to be the average of the estimates of color:

COLOR OF NOVA PERSEI AT MAXIMA AND MINIMA.

Maxima.		Minima.	
Date.	Color.	Date.	Color.
Feb. 23	White or pale yellow.	Feb. 27	.....
26	Yellowish white.	Mar. 1	Orange.
28	Pale yellow.	13	Yellow.
Mar. 12	Reddish white.	16	Yellowish red.
15	Yellowish red.	19	Clear red.
17	Full orange.	21	Red.
20	Blue.	25	Red.
23	White.	28	Very red.
27	Light orange to very red.	April 3	Orange red.
Apr. 1	Orange yellow.	7	Red.

COLOR OF NOVA PERSEI AT MAXIMA AND MINIMA.—Continued.

Maxima.			Minima.		
Date.		Color.	Date.		Color.
Apr.	4	Orange.	Apr.	10	Red.
	9	Pale red.		15	Reddish yellow.
	12	Reddish white.		21	Very red.
	18	Whitish yellow.		25	Red.
	23	Almost white.		29	Very red.
	27	Yellow.	May	6	Very red.
May	2	Yellow.		11	Very red.
	7	.....		15	Very red.
	13	Absence of red noted.		20	More red.
	18	.....		24	Very red.
	22	.....	June	1	Red.
	30	Orange yellow.		6	Dull yellow.
June	3	.....		10	Red.
	8	Not very red.		17	.....
	...	.....		23	Very red.
	22	Yellow.		25	Red.
	24	White.			Yellowish green.

During July the red color was very much diminished and later the star is generally recorded as white or colorless.

It has not been a part of my plan in this paper to offer any explanation of the phenomena of the new star. This ought not to be attempted without a thorough collation and exhaustive study of the spectroscopic observations, large numbers of which are to be found in the various astronomical publications. The latter task I have not the necessary time to take up, but I understand that it is being undertaken at the Observatory of Potsdam.

ADDITIONAL OBSERVATIONS.

Peridier, J. M., Paris. MSS. of unpublished observations. The observations extend from Mar. 3 to April 19 and from Aug. 6 to Oct. 12, 1901. With one exception, they were made with a binocular of low power. On Aug. 30 a telescope was used. The method of Argelander was employed in the comparisons and the reductions were made to the Harvard system. In the column headed "Sky" 1 signifies weather fine; 2, less favorable; 3, quite unfavorable; M signifies moonlight.

Gr. M. T.			Sky.	Comparisons and Remarks.	Redu'd Mag
Mar.	h	m			
3	7	40	3 M	β 3 N Moon almost full	2.60
	8	20	2 M	β Tauri 2 N 5 ϵ Thick clouds; light reddish	2.44
8	7	31	2	β 5 N 2 ϵ Reddish	2.74
14	8	35	2	ϵ 2 N 6 ν A little less reddish	3.19
16	7	60	1	ν 2 N 7 *l* N always reddish	4.26
22	8	25	2	*l* N (71); *l* 1 N 3 (72)	5.20
24	9	40	1 M	ν 1 N 8 *l* N garnet color	4.16
26	7	40	1 M	ν 3 N 5 *l* N orange	4.41
27	7	25	2 M	ν 1 N 2 κ N pale orange; between 2 falls of snow	3.93
29	7	25	1 M	ν 5 N 4 *l*	4.56
30	7	35	2 M	ν 4 N 6 *l* Fog.	4.41

Gr. M. T.			Sky.	Comparisons and Remarks.	Redu'd Mag
April	h	m			
4	7	55	1	ν 3 N 2 σ; κ 1 N 1 ψ Orange	4.19
7	8	00	1	*I* 2 N 1 (72) Pale red	5.35
12	7	57	1	ν 9 N 1 *I* Pale orange	4.91
17	8	41	1	*I* 1 N Always orange	5.23
19	8	35	1	*I* 2 N	5.33
Aug.					
6	9	40	1	(83) 1 N Seeing splendid	6.60
7	10	00	1	(71) 3 N; (72) 2 N Good seeing	5.57
8	9	50	1	(83) 1 N 5 (85)	6.65
9	10	20	1	N 1 (83) Damp	6.40
12	10	23	2	(72) 1 N	5.47
13	11		1	(83) 3 N 8 (85)	6.60
14	9	49	2	(83) 3 N 6 (85)	6.7
15	9	44	1	N 2 (83)	6.3
17	9	45	1	(72) 3 N 7 (83) Light haze	5.73
18	9	50	1	(83) 2 N	6.7
20	10	10	1	N 2 (83)	6.3
21	10	25	1	N 1 (83)	6.4
22	10	17	1 M	N 1 (83)	6.4
27	10	40	1 M	N 2 (83)	6.3
28	10		1 M	N 2 (83)	6.30
30	10	05	1 M	N 4 (83)	6.10
Sept.					
2	10	10	2 M	(83) 2 N Clouds	6.70
5	10		1	(83) 2 N 5 (85)	6.70
7	10	55	1	(83) 5 N 2 (85)	7.00
8	9	10	2	(83) 4 N 3 (85)	6.90
9	10	40	2	(83) 4 N Haze	6.90
13	9	50	1	(83) 5 N 2 (85)	7.00
14	9	54	1	(83) 3 N 4 (85)	6.80
15	10	17	1	(83) 2 N 5 (85)	6.70
16	10		1	(83) = N Clouds	6.50
17	9	47	1	N 1 (83)	6.40
18	9	57	1	N 1 (83)	6.40
19	10	15	1	(83) 3 N 2 (85)	6.90
Oct.					
3	9	15	1	(83) 4 N 3 (85)	6.90
5	9	27	1	(83) 2 N	6.70
7	9	27	1	(83) 4 N 3 (85)	6.90
8	8	30	1	N 1 (83)	6.40
10	10	54	1	(83) 2 N	6.70
11	8	42	2	N 2 (85)	7.00
12	10	40	1	N 2 (85)	7.00

PLANET NOTES FOR MAY.

H. C. WILSON.

Mercury will be visible as evening star, near the western horizon just after sunset, during the latter part of May. The planet will be at greatest eastern elongation at noon, May 28.

Venus, having just passed greatest western elongation will be conspicuous as morning star, seen toward the southeast for two hours before sunrise, during May. Venus and the waning Moon will be in conjunction, the latter 4° 19′ north of the former on the morning of May 4.

Mars is on the farther side of the Sun and not yet far enough out from the glow of that body to be easily observed.

Jupiter will be at quadrature, 90° west from the Sun, on the morning of May 7 and so may be observed near the meridian before sunrise.

Saturn is a few degrees to the west of Jupiter, and may therefore be observed at the same time. Both planets are at too low an altitude, at best, to be observed well. The Moon will pass Saturn on the morning of May 27 and Jupiter on the evening of May 28.

THE CONSTELLATIONS AT 9 P. M. MAY 1902.

Uranus may be observed near the meridian about 2 o'clock in the morning, but always at too low an altitude for satisfactory views.

Neptune is too low in the west now, in the early evening, for good seeing. On May 29, at 9^h A. M. Central Standard Time, Neptune and Mercury will be in conjunction, the former being 2° 52′ south of the latter.

A Partial Eclipse of the Sun will occur on May 7, but will be visible only in the regions of Antarctic and South Pacific Oceans.

ELEMENTS OF THE ECLIPSE.

Greenwich Mean Time of conjunction in right ascension, May 7^d 19^h 12^m $15^s.6$

Sun's and Moon's R. A.	2^h	55^m	$42^s.04$	Hourly motion	$9^s.68$	&	$153^s.70$
Sun's declination	16°	44′	50″.4N	Hourly motion	0′	41″.6N	
Moon's declination	15	37	34 .4N	Hourly motion	7	31	.2N
Sun's equa. hor. parallax			8 .7	Sun's true semidiam.	15	50	.6
Moon's equa. hor. parallax		61	02 .1	Moon's true "	16	38	.0

CIRCUMSTANCES OF THE ECLIPSE.

		Gr. M. T.			Longitude from Gr.			Latitude		
Eclipse begins	May 7^d	08^h	$42^m.5$		161°	53′.8E		52°	53′.5S	
Greatest eclipse		7	10	34 .3		125	16 .7W		70	00 .1S
Eclipse ends		7	12	26 .3		108	29 .7W		32	24 .7S

Magnitude of greatest eclipse = 0.858 (Sun's diameter = 1.0),

The Moon.

	Phases.	Rises. (Central Standard Time at Northfield Local Time 13m less.)		Sets.	
		h	m	h	m
May 7	New Moon	4	45 A. M.	7	22 P. M.
13-14	First Quarter	10	48 "	12	49 A. M.
21-22	Full Moon	7	06 P. M.	4	55 "
30	Last Quarter.	12	29 A. M.	12	14 P. M.

Occultations Visible at Washington.

Date. 1902.	Star's Name.	Magnitude.	IMMERSION. Washington M. T. h	m	Angle from N pt. °	EMERSION. Washington M. T. h	m	Angle from N pt. °	Duration. h	m
May 9	*m* Tauri	5.1	5	56	158	6	24	210	0	28
11	λ Geminorum	3.6	8	14	99	9	13	292	0	59
13.	κ Cancri	5.1	5	40	98	6	59	311	1	19
14	14 Sextantis	6.6	10	28	152	11	20	255	0	52
18	28 Virginis	7.0	15	42	91	16	34	298	0	52
19	α Virginis	1.2	13	48	152	14	35	237	0	47
20	a^1 Librae	6.3	5	38	116	6	43	283	1	05
20	a^2 Librae	2.9	5	46	122	6	51	277	1	04
22	B.A.C. 5580	5.7	13	17	97	14	48	267	1	31
28	c^1 Capricorni	5.2	15	55	59	17	23	249	1	28
28	B.A.C. 7562	5.5	15	57	48	17	22	261	1	25

COMET AND ASTEROID NOTES.

Comet 1895 II (Swift).—Mr. F. E. Seagrave sends us the following ephemeris of Swift's comet 1895 II, based upon the elements computed by Mr. Herbert R. Morgan, *A. J.* No. 451. No corrections for perturbations have been applied, but during the interval since 1895 the comet has not been near any of the large planets. Mr. Seagrave says, "When this comet is so situated in its orbit that its eccentric anomaly is 225° 20′, it is extremely close to the orbit of Jupiter. This was the case on Sept. 9, 1900, but Jupiter was then nearly 75° farther east in longitude. The following figures will show how near the comet goes to Jupiter's orbit:

	λ			β			log. *r*
Comet 1900 Sept. 9	179°	45′	05″	+0°	29′	10″	0.73628
Jupiter 1898 Jan. 1	179	3	20	+1	17	18	0.73628

At times there must be nearer approaches of the two bodies.

The comet will be so faint that it is doubtful if it can be seen after the middle of November."

EPHEMERIS OF COMET 1895 II (Swift).

[Computed by F. E. Seagrave.]

r	Washington M. T.			α			δ			log Δ	log r
°	1902.	h	m	h	m	s	°	′	″		
−50	Sept. 2	23	48	16	15	55.70	−17	54	37.76	0.0920301	0.1836588
−45	10	8	49	16	31	10.41	−18	46	20.56	0.0957133	0.1712992
−40	17	13	4	16	47	54.91	−19	34	55.53	0.0986385	0.1598680
−35	24	13	1	17	6	0.56	−20	18	27.79	0.1009981	0.1494716
−30	Oct. 1	9	3	17	25	20.81	−20	55	10.38	0.1029660	0.1402142
−25	8	2	10	17	45	50.54	−21	23	22.63	0.1048293	0.1321924
−20	14	16	15	18	7	20.98	−21	41	5.27	0.1066489	0.1254960
−15	21	4	29	18	29	46.58	−21	47	54.14	0.1088097	0.1202020
−10	27	14	56	18	52	58.85	−21	41	32.25	0.1114167	0.1163732
−5	Nov. 3	0	17	19	16	52.0	−21	21	15.92	0.1147922	0.1140564
0	9	9	6	19	41	16.34	−20	46	20.61	0.1190539	0.1132810
+5	15	17	54	20	6	2.60	−19	56	24.33	0.1244256	0.1140564
+10	22	3	15	20	31	1.98	−18	51	28.19	0.1311147	0.1163732
+15	28	13	42	20	56	7.01	−17	31	54.79	0.1392993	0.1202020
+20	Dec. 5	1	45	21	21	9.97	−15	58	34.86	0.1490694	0.1254960
+25	11	16	1	21	46	4.24	−14	12	43.02	0.1605239	0.1321924
+30	18	8	57	22	10	44.0	−12	15	58.05	0.1737045	0.1402141
+35	25	5	10	22	35	6.47	−10	10	5.41	0.1886498	0.1494716
	1903										
+40	Jan. 1	5	8	22	59	9.99	−7	57	2.50	0.2052826	0.1598680
+45	8	9	22	23	22	53.98	−5	38	53.06	0.2234987	0.1712990
+50	15	18	23	23	46	18.52	−3	17	44.07	0.2431596	0.1836588
+55	23	8	42	0	9	25.96	−0	55	29.53	0.2641253	0.1968381
+60	31	4	47	0	32	19.52	+1	26	3.74	0.2861731	0.2107312
+65	Feb. 8	7	7	0	55	2.33	+3	45	13.52	0.3090623	0.2252332

New Asteroids.—The following have been discovered since our last note:

	Discovered by		at		Local M. T.		R. A.		Decl.		Mag.
					h	m	h	m	°	′	
1902	HQ	Carnera	Heidelberg	Feb. 25	8	15.2	10	44.7	+14	40	11.8
	HR	Wolf	Heidelberg	Mar. 3	10	54.9	10	09.8	+12	24	14.5
	HS	Wolf	Heidelberg	3	13	09.9	11	43.5	+4	43	13
	HT	Wolf	Heidelberg	3	13	09.9	11	37.8	−1	21	12
	HU	Wolf	Heidelberg	4	13	09.9	11	26.3	+0	37	12

1902 HQ is apparently identical with (93) Minerva.

Orbit Elements of Asteroid (444) Gyptis.—In *Bulletin Astronomique* for March 1902 Mr. Louis Fabry, of the Paris Observatory, gives the following elements:

$M = 229° 44′ 21″.1$
$\omega = 151 34 22 .7$
$\Omega = 196 11 49 .2$ 1899.0
$i = 10 12 28 .8$

$\phi = 10° 00′ 34″.5$
$\mu = 768″.8324$
$\log a = 0.4427834$

Orbit Elements of Asteroid 446 Æternitas.—In *A. N.* 3779 Mr. W. Pauly of Bukarest gives the following elements based upon five normal places in 1899 and two observations in January 1901:

Epoch 1899, Oct. 30.0 Berlin Mean Time.

$M = 55° 26′ 20″.6$
$\omega = 277 33 20 .0$
$\Omega = 42 32 45 .7$ 1900.0
$i = 10 39 00 .7$

$\phi = 7° 07′ 03″.2$
$\mu = 761″.5980$
$\log a = 0.4455205$

The asteroid was at opposition April 4. A portion of the ephemeris for May is here given.

EPHEMERIS OF ASTEROID (446) AETERNITAS.

	R. A.	Decl.	log r.	log Δ.
	h m s	° ′		
May 2	12 29 45	+3 57.9	0.4696	0.3179
4	28 37	3 56.3	.4693	.3208
6	27 33	3 54.1	.4690	.3239
8	26 34	3 51.3	.4686	.3271
10	25 41	3 48.0	.4683	.3304
12	12 24 53	+3 44.1	0.4680	0.3339

Magnitude 12.0.

Orbit Elements of Asteroid (449) Hamburga.—In *A. N.* 3773 Professor J. Möller, of the Kiel Observatory, gives the following elements based upon eight normal places from the observations in 1899 and 1901:

Epoch 1901, March 20.0 Berlin M. T.

$M = 38° 07′ 28″.0$
$\omega = 44 38 43 .3$
$\Omega = 85 51 54 .1$ 1900.0
$i = 3 06 04 .8$

$\phi = 10° 03′ 32″.4$
$\mu = 870″.988$
$\log a = 0.406664$
$m_0 = 11^m.8 \quad g = 8.8$

Orbits Elements of Asteroids (473) (474) (478) and 1901 HL.—In *A. N.* 3775 Dr. A. Berberich gives the following elements, all being somewhat uncertain because of the short intervals of time:

	(473)	(474)	(478)	HL.
		Berlin M. T.		
Epoch	1901 Feb. 13.5	1901 Mar. 13.5	1901 Oct. 27.5	1902 Jan. 15.5
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
$M =$	95 13 40.1	223 19 18.1	269 23 35.1	13 46 43.0
$\omega =$	57 06 44.0	142 45 11.8	239 25 07.8	254 19 36.2
$\Omega =$	333 27 34.7	162 47 45.3	234 51 20.9	172 51 23.5
$i =$	27 46 28.2	7 32 26.2	13 06 37.5	3 30 50.3
$\phi =$	14 48 41.2	8 27 23.1	4 51 57.5	8 47 44.3
$\mu =$	690″.051	916″.700	677″.866	727″.742
$\log a =$	0.474084	0.391853	0.479242	0.458686

1902 HL is identical with (358) Apollonia. The epoch of the latter, given in the *Berliner Jahrbuch* for 1902 to 1904 should be 1893, Mar. 10.5 instead of 1893, Mar. 3.5. The elements of HL are referred to the mean equinox of 1902.0, the others to that of 1901.0.

Orbit Elements of Asteroid (476) Hedwig.—In *A. N.* 3773 Dr. E. Strömgren gives the following elements, based upon 14 observations in August, 2 in September and 1 on Dec. 5, 1901:

Epoch 1902 Dec. 10.0 Berlin M. T.

$M = 156° 21′ 50″.49$
$\omega = 356 55 06 .13$
$\Omega = 286 32 59 .74$ 1900.0
$i = 10 56 37 .47$

$\phi = 4° 16′ 02″.09$
$\mu = 823″.2035$
$\log a = 0.4229996$

Orbit Elements of Asteroid 479 1901 HJ.—The following elements are given Dr. Bauschinger in *A. N.* 3775. They depend upon three normal places Nov. 15.5, Nov. 28.5 and Dec. 7.5, 1901:

Epoch 1901, Nov. 15.5 Berlin M. T.

$M = 2° 12′ 53″.0$
$\omega = 269 14 23 .8$
$\Omega = 136 23 37 .2$ 1900.0
$i = 8 39 27 .5$

$\phi = 12° 42′ 44″.4$
$\mu = 788″.048$
$\log a = 0.435636$

VARIABLE STARS.

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with midnight. The hours greater than 12 are those of the afternoon. To obtain Eastern Standard time subtract 5 hours; for Central Standard subtract 6 hours.]

U Cephei.

	d	h
May	2	22
	5	10
	7	22
	10	9
	12	21
	15	9
	17	21
	20	9
	22	20
	25	8
	27	20
	30	8

Algol.

May	3	13
	6	9
	9	6
	12	3
	15	0
	17	21
	20	17
	23	14
	26	11
	29	8

R Canis Maj.

May	2	1
	3	4
	4	7
	5	11
	6	14
	7	17
	8	21
	10	0
	11	3
	12	6
	13	10
	14	13
	15	16
	16	19
	17	23
	19	2
	20	5
	21	8
	22	12
	23	15
	24	18
	25	22
	27	1
	28	4
	29	7
	30	11
	31	14

S Cancri.

	d	h
May	2	23
	12	11
	21	22
	31	10

S Antliæ.

Period $7^h\ 46^m.8$

May	1	15
	2	15
	3	14
	4	13
	5	13
	6	12
	7	11
	8	11
	9	10
	10	9
	11	9
	12	8
	13	7
	14	7
	15	6
	16	5
	17	5
	18	4
	19	3
	20	3
	21	2
	22	1
	23	1
	24	0
	24	23
	25	23
	26	22
	27	21
	28	21
	29	20
	30	20
	31	19

δ Libræ.

May	3	3
	5	11
	7	19
	10	3
	12	10
	14	18
	17	2
	19	10
	21	18
	24	2

δ Librae Cont.

	h	d
May	26	10
	28	17
	31	1

U Coronæ.

May	1	11
	4	22
	8	9
	12	20
	15	7
	18	17
	22	4
	25	15
	29	2

U Ophiuchi.

May	1	1
	1	21
	2	18
	3	14
	4	10
	5	6
	6	2
	6	22
	7	18
	8	15
	9	11
	10	7
	11	3
	11	23
	12	19
	13	15
	14	11
	15	7
	16	4
	17	20
	18	16
	19	12
	20	8
	21	4
	22	1
	22	21
	23	17
	24	13
	25	9
	26	5
	27	1
	27	21
	28	18
	29	14
	30	10
	31	6

Z Herculis.

	d	h
May	1	18
	3	19
	5	18
	7	19
	9	18
	11	19
	13	18
	15	19
	17	17
	19	19
	21	17
	23	19
	25	17
	27	18
	29	17
	31	18

RX Herculis.

May	1	15
	2	13
	3	10
	4	7
	5	4
	6	1
	6	23
	7	20
	8	17
	9	15
	10	12
	11	9
	12	7
	13	4
	14	1
	14	22
	15	19
	16	16
	18	13
	19	10
	20	7
	21	4
	22	1
	22	23
	23	20
	24	17
	25	15
	26	12
	27	9
	28	7
	29	4
	30	02
	30	23

V[3] Cygni

	d	h
May	6	6
	12	6
	18	6
	24	6
	30	6

U[3] Cygni.

May	1	8
	5	21
	10	11
	15	1
	19	15
	24	4
	28	18

W Delphini.

May	2	4
	6	23
	11	18
	16	13
	21	9
	26	4
	30	23

Y Cygni.

May	2	4
	3	12
	5	4
	6	12
	8	4
	9	12
	11	4
	12	12
	14	4
	15	12
	17	3
	18	11
	20	3
	21	11
	23	3
	24	11
	26	3
	27	11
	29	3
	30	11

Variable Stars of Short Period not of the Algol Type.

	Minimum.	Maximum.		Minimum.	Maximum.
	h	h		h	h
S Sagittae	May 1 13	May 14 23	X Cygni	May 16 18	May 23 13
W Sagittarii	1 17	4 17	W Sagittarii	16 21	19 21
Y Sagittarii	1 21	3 16	X Sagittarii	17 0	19 21
T Vulpeculae	1 22	3 7	β Lyrae	17 12	20 21
U Aquilae	1 23	4 3	η Aquilae	17 14	19 20
X Sagittarii	3 0	5 21	S Sagittae	18 7	21 17
η Aquilae	3 5	5 11	Y Sagittarii	19 5	21 0
W Geminorum	3 15	6 6	T Vulpeculae	19 15	21 0
β Lyrae	4 14	7 23	U Sagittarii	20 11	23 10
ζ Geminorum	5 11	10 11	δ Cephei	21 14	23 5
δ Cephei	5 12	7 3	U Aquilae	23 1	25 5
T Vulpeculae	6 8	7 17	T Monocerotis	23 1	30 23
U Sagittarii	6 23	9 22	β Lyrae	23 23	27 1
Y Sagittarii	7 16	9 11	X Sagittarii	24 1	26 22
W Virginis	8 10	16 14	T Vulpeculae	24 2	25 11
U Aquilae	9 0	11 4	W Sagittarii	24 12	27 12
Y Ophiuchi	9 6	15 11	η Aquilae	24 18	27 0
W Sagittarii	9 7	12 7	Y Sagittarii	24 23	26 18
S Sagittae	9 22	13 8	W Virginis	25 17	2 21
X Sagittarii	10 0	12 21	ζ Geminorum	25 19	30 19
η Aquilae	10 10	12 16	Y Ophiuchi	26 8	1 13
T Vulpeculae	10 19	12 4	S Sagittae	26 16	30 2
δ Cephei	10 21	12 12	δ Cephei	26 23	28 14
β Lyrae	11 1	14 3	U Sagittarii	27 5	30 4
W Geminorum	11 8	13 23	T Vulpeculae	28 12	29 21
Y Sagittarii	13 10	15 5	U Aquilae	30 1	1 5
U Sagittarii	13 17	16 16	β Lyrae	30 10	2 19
T Vulpeculae	15 5	16 14	Y Sagittarii	30 18	1 13
ζ Geminorum	15 15	20 15	X Sagittarii	31 1	2 22
U Aquilae	16 0	18 4	η Aquilae	31 22	3 4
δ Cephei	16 5	17 20			

Maxima and Minima of U Pegasi.

[Period 4h 29m 8s; the minimum takes place 2h 15m after the maximum.]

d h	d h	d h	d h
May 1 20	May 9 22	May 17 19	May 25 20
2 19	10 20	18 22	26 18
3 22	11 19	19 20	27 21
4 20	12 22	20 19	28 20
5 19	13 20	21 22	29 18
6 22	14 19	22 20	30 21
7 20	15 22	23 18	
8 19	16 20	24 21	

Variable (?) Star 2 1902 Lacertæ.—In *A. N.* 3774 attention is called by Professor K. Graff to the star BD + 54°.2863, R. A. $22^h\ 41^m\ 48^s.6$; Decl. + 54° 23′.8 (1855), which possibly varies between 9.5^m and 8.6^m. Its color is yellowish red.

New Variable Star 3, 1901, Monocerotis.—In *Astr. Nach.* 3775 Professor W. Ceraski announces a new variable star, discovered by Mme. Ceraski in studying the photographs of M. S. Blajko at the Moscow Observatory. The star is BD + 6°.1462, 8.0^m, R. A. $6^h\ 50^m\ 37^s.4$; Decl. + 6° 21′.4 (1855.0). At present (Feb. 14, 1902) it is of the 7th magnitude and near maximum, reddish. The Moscow photographs do not permit a determination of the period, which does not appear to be of short duration. Editor Kreutz adds that

the variable is the red star Kr. 654 = Birm.$_2$ 208 = Esp. 168. Espin's estimates are: 1886 Nov. 30 $7^m.5$ very orange red; 1887 March 22 $8^m.0$ red; 1888 Jan. 9 $8^m.2$ red. In the Leipzig Zones it was observed twice: Z. 618 $8^m.2$ 1886 Feb. 28 and Z. 703 $7^m.0$ 1887 Feb. 13. The spectrum is of Type IV.

New Variable Star 4, 1902, Geminorum.—In *A. N.* 3782 Professor W. Ceraski, of Moscow, announces as variable the star

BD + 20°.1875; R. A. $7^h\ 32^m\ 3^s.0$; Decl. + 20° 45′.3 (1855) Mag. 9.0.

The variability was discovered by Mme. Ceraski in examining the photographs taken by M. S. Blajko, and has been verified visually by the latter. At present, (Mar. 23, 1902) the brightness of the star is increasing.

Maxima and Minima of Long Period Variables.

[Computed from Chandler's "Third Catalogue" by Misses Ida I. Watson and Helen M. Swartz of Vassar College Observatory.]

Maxima.			Maxima.		
Date.	No.	Star.	Date	No.	Star.
May.			June.		
3	5494	S Libræ	11	5501	S Serpentis
7	2100	U Orionis	13	5338	U Bootis
8	7448	W Aquarii	15	5776	X Scopii
8:	7590	Z Capricorni	15:	7234	R Capricorni
9	5601	S Ursæ Minoris	18	906	R Trianguli
11:	7456	RR Cygni	19:	5566	RU Libræ
12	4492	Y Virginis	19	7571	V Capricorni
15:	3264	W Cancri	22	2528	R Geminorum
17	845	R Ceti	22	6512	T Herculis
17	1577	R Tauri	27	3567	V Leonis
19	893	U Ceti	30	7560	R Vulpeculae
19	2258	V Aurigæ		Minima.	
21	976	T Arietis	May.		
21	4511	T Ursæ Majoris	8	1944	S Orionis
21	8068	S Lacertæ	10	7754	W Cygni
22	1771	R Leporis	13	4521	R Virginis
22	5856	W Ophiuchi	16	2976	V Cancri
24	7261	R Delphini	18	432	S Cassiopeæ
26	806	*o* Ceti	26	1981	S Camelopardalis
27	4407	R Corvi	27	8324	V Cassiopeæ
27	6849	R Aquilæ	29	2478	R Lyncis
28:	294	W Cassiopeæ	June		
June.			1	2625	V Geminorum
2	782	R Arietis	3	6921	S Sagittarii
2	7242	S Aquilæ	4	6207	Z Ophiuchi
6	7192	Z Cygni	5	7252	W Capricorni
8:	5438	Y Libræ	6	114	S Ceti
8:	7907	U Aquarii	13:	1805	V Orionis
10	5430	T Libræ	22	5157	S Bootis
11	3184	T Hydræ	26	7577	X Capricorni
			29	466	U Piscium

Variable Stars.—The following observations of variable stars include a few maxima and minima and were carefully taken under favorable conditions. The comparison stars used are those in the variable star charts of Harvard, or those furnished in POPULAR ASTRONOMY. The estimates were made with a four inch telescope except occasionally when an opera glass was suitable.

S TAURI.

1901, Dec.	10	Invisible	1902, Jan.	7	12 magnitude.
	15	"		10	" "
	19	"		26	Brighter than the two adjacent stars and probably of about 10th magnitude.
	30	"		28	
1902, Jan.	2	"		31	
	4	"	Feb.	2	

The maximum was predicted for Jan. 31.

R TAURI.

The minimum was predicted for Dec. 28, 1901.

1901, Dec.	10	Invisible	1902, Jan.	2	A star of the 12th magnitude in the place of the variable is just discernible.
	15	"		4	
	19	"		7	
	30	"		10	
			Feb.	2	

U GEMINORUM.

1902, Jan.	4	A star of 11.5 magnitude was discernible near the place of the variable.	1902, Jan.	31	A star of 11th magnitude is discernible south of that of 11.5 magnitude.
	6		Feb.	2	
	7			12	
	8				
	8				
	10				
	16				
	26				

U ORIONIS.

Minimum Dec. 13, 1901.

1901, Dec.	12	Invisible in low power.	1902, Jan.	7	11.5 magnitude.
	15	" "		8	" "
	18	" "		11	" "
	19	" "		12	" "
	30	" "		26	Slightly brighter.
1902, Jan.	2	11.5 magnitude.		29	" "
	4	" "	Feb.	2	Equal to the adjacent star of 11 magnitude.
	6	" "		12	About 0.2^m brighter than the adjacent star.

W LYRÆ.

As during the maximum of last summer, this variable again attained its greatest luster some weeks before the predicted date, which was March 9, 1902.

Jan. 11	6:00 A. M.	Half a magnitude brighter than *n*.
20	6:00 A. M.	Equal to *n* but brighter than *a*.
27	5:45 A. M.	Distinctly brighter than *n*, probably half a magnitude. The color yellowish. Morning very clear.
Feb. 12	5:40 A. M.	Rather brighter than *n*; distinctly brighter than *a*.
22	5:30 A. M.	Equal to *n*.
Mar. 13	5:30 A. M.	Dimmer than *a* but equal to *p*, which is of 9.4 magnitude.

V ORIONIS.

This faint orb sometimes attains a magnitude of 8.4, but on Jan. 18, the date of its predicted maximum, the variation was probably less, according to the following estimates:

1902, Jan.	4	10.5 magnitude	1902, Jan.	19	10.5 magnitude.
	6	" "		26	" "
	7	" "		27	" "
	8	" "		28	11 magnitude.
	10	" "		29	" "
	12	" "		31	10.5 magnitude.
	15	" "	Feb.	2	" "
	16	" "			

The star south preceding V Orionis, to which attention is called in POPULAR ASTRONOMY for January 1895, p. 217, was of only about 12 magnitude on the above dates.

R URSÆ MAJORIS.

The maxima of this star vary from 6 to 8.2 magnitude. The recent maximum was due on Feb. 8.

1902, Jan. 31, Feb. 2, 12 } U is equal to *n* but not to *g*, which seems slightly brighter. Both are classed as of 8th magnitude.
Mar. 14 Decreased to *n*; 9th magnitude.
24 It is dimmer than *p* of 10th mag., and probably about 10.3^m.

L^2 PUPPIS.

The maximum of this star was due Feb. 28.

1902, Jan. 31, Feb. 12, Mar. 2, 9 } Brighter than 4^m; compared with σ Puppis of 3.4^m, and L^1, 5^m.
14 Slightly brighter than *b* Puppis, classed as 4.8^m.

U AURIGÆ.

1901, Dec. 10, 12, 15, 18, 30, 1902, Jan. 2 } Brighter than the two stars of 11.5^m with which it forms a triangle.

1902, Jan. 4 11 magnitude.
6 " "
7 " "
12 " "
17 " "
25 Nearly of 10th magnitude
26 " " "
31 " " "

In the *Companion to the Observatory* the maximum was predicted for March 15, and was no doubt observed elsewhere. ROSE O'HALLORAN.

SAN FRANCISCO, Mar. 25, 1902.

κ Persei.—In *A. N.* 3778 Dr. L. Grabowski of Poulkova investigates, from his own observations of 14 stars during the summer and autumn of 1901, the question of variability of κ Persei, which was raised by Dr. P. Guthnick in *A. N.* 3730. His conclusion is that there is little ground for assuming the star to be variable.

Proper Motion of Nova Persei.—In *A. N.* 3778 Professor Deichmüller gives the results of meridian observations of Nova Persei, made at Bonn in 1901 and 1902. They show that the proper motion of the star is exceedingly small. The following are the means of observations on five dates in each year:

	α 1901.0	δ 1901.0
1901.17	3^h 24^m 28^s.14	+43° 33′ 53″.95
1902.12	3 24 28 .15	+43 33 53 .8

OBSERVATIONS OF NOVA PERSEI.

Eastern Standard Time.				J. Day	Comparison	Magnitude.
	m	d	h m			
1902	1	24	8 10	2415774	*l* ½ V 4½ *m*	7.64
"	"	25	7 35	75	*l* 2 V 3½ *m*	7.68
"	"	"	7 45	"	*l* 1½ V 3½ *m*	7.72
"	"	27	7 55	77	*l* 2 V 3½ *m*	7.75
"	"	"	8 10	"	*l* 2½ V 3 *m*	7.79
"	"	28	8 30	78	*l* 2 V 3½ *m*	7.75

F. E. SEAGRAVE.

PROVIDENCE, Jan. 29, 1902.
The star *l* is DM +43°720 and *m* is DM 43°766. H. C. W.

Nova Persei Nebula.—In a letter to the editor of the *Astronomische Nachrichten* (*A. N.* 3779) Professor Wolf of Heidelberg says: "Yesterday, Mar.

5, I obtained a fine four hour exposure upon Nova Persei. The earlier knots have all become fainter. A new long zone of bright nebulosity extends toward the southwest from the Nova, much brighter than all the other condensations. This zone was very bright on Feb. 3 (last exposure). On Dec. 16 it was just outside of the star disc. On Nov. 17 it extended very faint out from the star disk. It is interesting, that the later nebulosity is brighter than the knots of August.

Comparison Stars for Nova Persei.—In *A. N.* 3779 Messrs. G. Müller and P. Kempf of the Potsdam Observatory give results of their photometric determinations of the magnitudes of the stars in Hagen's first and second catalogues of comparison stars for Nova Persei. As the magnitudes of the second catalogue may be of immediate use to some of our readers we give them here. They are of course reduced to the Potsdam system of magnitudes.

STARS OF HAGEN'S CATALOGUE II.

No.	BD.	1900 R. A.	Decl.	Magnitudes. Hagen.	BD.	Potsdam.	Color.	No. Obs.
	°	h m	° ′	m	m	m		
1	43 730	3 21.5	+ 44 02	7.1	7.0	6.57	Y+	10
2	44 734	3 25.8	+ 44 31	7.4	6.5	6.61	YW —	8
3	44 732	3 25.4	+ 44 30	7.5	7.5	7.16	Y	4
4	44 742	3 27.8	+ 44 28	7.6	7.3	7.50	WY +	4
5	44 732	3 21.8	+ 43 24	7.7	7.5	7.41	W +	6
6	43 720	3 20.1	+ 43 18	7.8	7.6	7.36	WY +	4
7	43 766	3 28.5	+ 43 31	7.9	8.0	7.82	WY +	4
8	43 728	3 21.2	+ 44 03	8.1	8.4	8.32	YW	4
9	44 717	3 23.7	+ 44 29	8.2	8.5	8.63	YW —	6
10	43 726	3 20.9	+ 43 50	8.3	8.9	Var.	Y +	—
11	43 744	3 25.2	+ 43 20	8.4	8.6	8.69	YW	4
12	43 729	3 21.2	+ 44 00	8.5	8.7	8.70	YW	4
13	44 712	3 21.9	+ 44 18	8.6	8.9	8.81	WY	6
14	44 741	3 27.8	+ 44 15	8.7	9.1	8.99	WY —	4
15	43 723	3 20.6	+ 43 22	8.7	9.1	8.96	YW +	4
16	44 721	3 24.5	+ 44 19	8.7	8.9	8.92	YW —	6
17	43 740	3 24.3	+ 43 52	8.8	8.8	9.22	YW	4
18	44 746	3 25.6	+ 43 11	8.8	9.1	9.03	YW	6
19	44 724	3 24.8	+ 44 12	8.8	9.0	9.05	WY	6
20	43 739	3 24.0	+ 43 38	8.9	9.0	9.11	YW	6

OBSERVATIONS OF NOVA PERSEI.

1901.	Hour.			
June 9	15.7	(71) 2 (72) 1 N	Greenish-white	
10	15.5	(68) & (72) & (71) > N; N > (83)		
12	15.0	(68) 2 (71) 2 (72) 1 N > (83)		
July 4	14.5	(72) 2 N = (75) = (79) 1 (78) 2 (80)		
19	14.7	N 2 (83) 2 (81) 1 (82)		
21	15.5	(80) 2 N 1 (81) 2 (82) 1 (83)		
31	15.0	(80) 1 (83) 2 N; (75) & (78) & (79) > N		
Aug. 7	13.0	N = (83)		
18	15.5	(81) = N 2 (83)		
19	15.0	(72) 3 N = (79)		
Sept. 4	9.7	Nova between 6.5 and 7.0 mag.	Greenish or bluish	5″ teles.
23	9.3	N 4 (85) 6 (87)	Green	5″ "
Oct. 4	8.5	(82) 1 N 3 (85)		
5	9.0	N 2 (84)	Green	5″ "
7	8.3	N 1 (85); N > (83) or 44°714		
8	10.0	N 1 (83) = (82)		
9	9.5	N 2 (85)		
11	7.3	(83) 2 N 3 (85); (82) > N		
13	7 & 9.5	(83) 4 N 3 (85)		

OBSERVATIONS OF NOVA PERSEI.—Continued.

1901.	Hour.			
Oct. 14	7.3	(82) 1 (83) 3 N 4 (85)		
15	7.3	(82) 1 (83) 2 N > (85)		
16	7.3	(82) = (83) 3 N 1 (81)	Greenish	5″ teles.
17	7.5	(83) 4 N 3 (85)		
18	7.5	(82) 1 (83) 2 N		
19	7.2	(83) 4 N 3 (85)		
20	9.7	Same		
21	8.0	(83) > N Moon		
30	6.7	(83) 4 N 3 (85)		
31	7.0	(83) 5 N 2 (85)		
Nov. 2	6.4	N 2 (85)	Green	5″ teles.
3	9.2	(81) 2 N 3.5 (85)		
6	6.0	44°714 = N 2 (85)		
7		Same		
8	7.6	Same		
9	9.2	N 1 44°714 1 (85)		
13	7.5	41°638 5 N 1 41°693 1 (85) 1 44°714		
14	7.3	Same		
18	10.3	Same		
30	6.5	N 2 (85) = 41°693 1 44°714		
Dec. 1	9.5	Same		
3	6.3	Same		
7	7.0	(83) 4 N 1 (85) 1 (87) 2 44°742		2″ teles.
8	9.5	Same		
10	6.5	Same		2″ teles.
12	8.0	41°693 = N 1 (85) 2 44°714		2″ teles.
15		Same		
17	7.2	41°693 1 N ½ 44°714		
30	7.2	N ½ 41°693 ½ (85)		
31	11.5	(85) 3 N 1 (87) 1 43°720		
1902.				
Jan. 3	6.5	(85) 2 N 2 (87)		
4	6.0	(85) > N 1 (87) 1½ 43°720		
6	6.7	(85) 2 N 1½ (87) 1½ 43°720		2″ teles.
9	7.5	N 3 (87) 1 43°720		
11	7.5	(85) 3 N 2 (87) 1 43°720		
13	6.6	Same		2″ teles.
14	6.4	Same		2″ teles.
Feb. 2	7.2	(87) 1 43°720 3 N		
3	7.2	(87) 1 43°720 2.5 N		
4	6.6	(87) 1 43°720 3 N		
7	7.4	(87) 1 43°720 3 N		
8	8.7	(87) 1 43°720 4 N		
10	7.4	(87) 1 43°720 4 N		

In all cases in which a telescope is not mentioned an opera glass magnifying 4 diameters was used. Part of these observations were made at the Leander McCormick Observatory and part at the Students Observatory, University of Virginia. The numbers used to designate comparison stars are those given in the October, 1901, issue of POPULAR ASTRONOMY.

No. (83) in every case, except in which a telescope is mentioned, consists of BD 44°734 and BD 44°732, as these appear as one in opera glass.

CHAS. P. OLIVIER.

UNIVERSITY OF VIRGINIA.

Variable Star 2.1902 Lacertæ.—In *A. N.* 3780 a note by Professor K. Graff states that the star is identical with Birm.$_2$ 735 and Espin 267 and that its magnitude as estimated by Espin in 1887 and 1893 was 8.2 and 8.5, while the BD gives it as 9.51. Its spectrum was of Espin's type IV.

GENERAL NOTES.

New Large Equatorial for Cincinnati Observatory.—Professor J. G. Porter, Director of the Cincinnati Observatory informs us of some of the details of the new large refracting telescope soon to be furnished for the Cincinnati Observatory. In a recent letter he says: "All I can say is, that after many years of careful saving, we now have the necessary funds on hand, and the contract has been awarded to Alvan Clark & Sons' Corporation for a 16-inch equatorial. It will be placed in the present 30-foot dome, that having been constructed with this special object in view. The instrument will be fitted for optical work only, it being the settled policy of this Observatory to devote its energies to the old astronomy of position. All the modern conveniencies for handling a telescope o this size, will, of course, be applied."

New Method of Converting Mean Time into Sidereal and the reverse.—In *A. N.* 3774 Dr. C. Börgen of Wilhelmshaven, gives a rather neat method of converting time without use of the ordinary tables. His formulæ are:

Reduction of mean to sidereal interval $= + (10t - 1/7t - 1/1500t)$ seconds,
Reduction from sidereal to mean $= - (10t - 1/6t - 1/250t)$ seconds,

in which t is the interval of time expressed in hours and decimals of an hour.

For $t = 24^h$ these formulæ give:

Reduction from mean to sidereal $= + (240^s - 3^s.4286 - 0^s.0160) = + 236^s.5554$.
Reduction from sidereal to mean $= - (240^s - 4^s.0000 - 0^s.0960) = - 235^s.9040$.

The first of these quantities is exact to four decimals, the second lacks $0^s.0054$ of the correct value. The second formula would be exact if the fraction in the third term were 1/256 or if a fourth term $+ 1/4500t$ were added.

If one were content with the reduction to tenths of seconds the third term in both formulæ might be neglected when the interval of time is less than 12 hours.

Zodiacal Light and the Gegenschein.—The brightness of the zodiacal light for the months of February and March of 1902 as seen from Goodsell Observatory has been very noticeable, even to the untrained eye. At nine o'clock on the evening of March 29 the display was remarkable, even clearer and more extended than ever before witnessed. On that occasion two observers of some experience could follow the zodiacal band to the meridian and faint traces of it could be seen far beyond. As might be expected the Gegenschein has been quite easily seen on occasions at night when the sky was quite clear and moonless. Since it has crossed the Milky Way observations of its brightness and extent are possible and much more satisfactory. It is not unusual that this great patch of light covers a space varying from 15° to 20° in diameter. Sometimes it is elliptical in form and sometimes it appears to be nearly circular. The gradual lessening of light from center to outlines makes it difficult to determine its form with the degree of certainty that the interested observer so much desires. Naked-eye observers with good sight can do nothing better than to watch the Gegenschein and to record systematically all their observations.

An Eclipse Cycle.—The following note from W. H. S. Monck came too late to be appended to his article on page 240 of this number:

"The eclipse cycle Period seems to be 190,295 days. This was 521 years in most instances under the old mode of reckoning but was a day short of 521 years when there were 131 leap years in the period. But in the new mode of reckoning, 521 years will never, I think, come more than 190,292 days and sometimes a day less. So the cycle will be 3 or 4 days later on each return."

Recent Changes in the Surface Markings of Mars.—In the April issue of *Knowledge* a very readable article, fully illustrated, gives the results of recent observations of Mars by E. M. Antoniadi in regard to changes in surface markings. The chief ones are:

1. The unaccountable disappearance of Aonious Sinus since the opposition of 1892.
2. The fading of the canal, once the darkest, Nelosyrtis.
3. The bridging of Syrtis Major by "Nili Pons."
4. The formation of the canal "Nasamon."
5. The great faintness of the Cereberus in 1894, and its extraordinary darkness during the apparitions of 1898-1899 and 1900-1901.
7. The increased darkness of the canals Amenthes and Nilokeras.
8. The darkness of Phlegra, Cebrenia Ætheria and Utopia together with the formation of the "Copais Lacus."

The writer of this article thinks that some of these changes occurring as they do, in the equatorial zone of Mars, can scarcely be accounted for by mere seasonal change. They cannot be charged to observational errors, nor mere cloud formations. These changes are still enigmas.

Variability of the Light of the Planet Eros.—A brief account of the variability of the light of the planet Eros will be found in No. 4 of the *Monthly Notices*, February, 1902. The discovery of this important feature of planet was made in February last by E. von Oppozer, and it has since been confirmed by other observers. The range has been about one magnitude. The probable period by one observer is $5^h\ 16^m$. This result is not definitely established. The three theories that have been suggested to account for this variation are:

1. "That the planet is double, consisting of two bodies revolving almost in contact in a period of $5^h\ 16^m$. Mutual occultations take place when the plane of motion passes through the Earth."
2. "That it is shaped like a dumb-bell; the further suggestion is made that two spherical bodies may have collided and adhered together. Mutual occultations would take place as above when Earth was in plane of motion."
3. "That the variation is simply caused by large differences of albedo in various parts of its surface."

The troublesome thing in these theories is that observations do not show a uniform variation in different periods of variation and in different months of the year.

Professor Eric Doolittle's marriage to Miss Sara Halliwell took place March 31, 1902 at Bethlehem, Pennsylvania. For a young man Professor Doolittle is widely known in the circle of astronomers and mathematicians. Hearty congratulations.

A Theory of the Cosmos is the title of an address by E. B. Knerr, as President before the thirty-second annual meeting of the Kansas Academy of Sciences. Though made over a year ago, a copy of the address has just reached us. A brief summary is found in the final paragraph which is as follows:

"Briefly stated, the conception of the cosmos which I wish to suggest is: The material universe is made up of matter in eternal motion. All is matter and motion of matter. The masses, as we know them about us, large and small, are

made up of molecules in motion. These molecules may meet and rebound or swing about each other in their movements, but they are never in permanent contact. So small are they that their existence cannot be detected as individuals by any of our senses, yet their existence is established by the principles of physics. The molecules in turn are conceived to be made up of atoms, to satisfy the demands of chemistry. And now, I hold that the atoms must be subdivided into protatoms, to conform to the demands of etherics; that in the motion of these various aggregates of matter inheres the energy of the universe—as energy of mass motion in the movements of sensible masses; as heat in the motion of molecules; as chemism in the motion of atoms; and as light, radiant heat, electricity, magnetism, gravity, in the motion of the protatoms of the ether; that the ether itself is made up of protatoms, as yet unassembled into atoms, more or less evenly distributed, with absolutely void spaces between them; that across these spaces the protatoms move unhindered until they collide with other moving protatoms, when they rebound with undiminished energy because of their perfect elasticity: that the energy of this ultimate individual protatomic vibration is gravity; that this protatomic vibration becomes transformed in the atomic, molecular, and mass aggregates into the resultant energy of organized waves; that the waves which are emitted on the sides of bodies facing each other are more or less neutralized, thus allowing of a greater pressure on the outer sides, and thereby causing the bodies to be driven together. Finally the theory presented discovers a complete cycle in the transformation of energy. Hitherto the energy dissipated into space has found no explanation for its conservation and return. The theory presented herein recovers that energy in gravity, ready to be again transformed in endless recurrent changes."

The Story of the Dial of Ahaz.—The Sun dial of Ahaz, as recorded in the 20th chapter of the Second Book of Kings, is an interesting story, and would be far more so, had it been correctly translated. It is the first instance in all history, of any mechanical device being used to measure the passing of time. Of course we know nothing as to its size and construction, but that it was intended to show the Sun's shadow as cast by a gnomon on a graduated circle is evident.

The record is so at variance with what the inspired writer intended to convey that I have long felt a desire to ventilate my views on the subject, and to publish them in some prominent scientific journal. I have no doubt but that they will meet with general acceptance from Bible readers and scientists.

The error in the translation, 2d Kings XX, 8, 9, 10, 11, arose from the author's laboring under the delusion that the miracle was in, or on, the dial, and not elsewhere, while I contend that it had no more to do with a miracle than a near by house or tree. All the dial had to do with it was, that Isaiah happened to go there to perform the miracle. Had he gone to some other place, and no dial been mentioned, there would have been no mistranslation. Why he went there instead of some other place is of course unknown, but a plausible reason is that the dial was located at a central and conspicuous place, where the Sun could shine on it from rising to setting, and therefore a usual place for people to meet, and quite likely many resorted there to witness the miracle.

For what object and for whose benefit was this stupendous miracle performed? Hezekiah was taken seriously ill, and Isaiah was deputed by the Lord to go to tell him he should die. In a few minutes in answer to Hezekiah's prayer, Isaiah returned and told him that he had again received word from the Lord that he should live fifteen years and in three days would be able to go up to the house

of the Lord. Hezekiah asked him what sign he would give him, and he replied, (King James' version) "wilt thou have the shadow go forth 10 degrees, or back 10 degrees?" In heavens name I ask what shadow? Is there but one shadow on our Earth? Remember no dial is mentioned yet. Hezekiah replied, that it is a light thing for the shadow to go down 10 degrees; nay let the shadow return back 10 degrees. The shadow to go down, is entirely destitute of meaning, for he was asked if he would have the shadow go forward or back, not down.

And Isaiah, the prophet, cried unto the Lord and he brought the shadow 10 degrees backward, by which it *had gone down* in the dial of Ahaz. The translators on their own responsibility, translated a Hebrew word degrees, which means steps, and in several places in the Bible is rendered steps, but laboring under the delusion that the dial was used, and failing to see what possible connection there could be between steps and a sun dial, translated it degrees, equally as incongruous as steps. As well might our clocks and watches be divided into degrees to tell the time. Sun dials are graduated to hours and minutes, not degrees.

The Revised Version is here superior to the Authorized, but is not exactly right. Its translators also labored under the delusion that the miracle was *on* the dial. For degrees, it reads steps, and *on* instead of *in* the dial.

The following are my renderings, which exactly convey the meaning the inspired writers intended, and free from mystification. Wilt thou have the *shadows* go forward 10 steps, or back 10 steps? It is a light thing for *shadows* to go forward; nay let them return 10 steps. And Isaiah the prophet cried unto the Lord, and he brought the shadows backward 10 steps, by the coming back of the Sun which had gone down *at* the dial of Ahaz. I have not access to the Revised Version, but I earnestly desire that Isaiah XXXIII, 8 be carefully read and compared with the other texts, the meaning of which must agree with the others quoted, for if not, the idea of their inspired authorship must be abandoned. I contend that if denuded of the errors of translation, they do exactly agree.

The reading and meaning of the version in Isaiah is briefly as follows: "So the Sun returned back by which it had gone down, to make the shadows go backward 10 steps at the dial of Ahaz.

The miracle of frogs, and lice, and locusts, and the dividing of the waters of the Red Sea, were terrestrial miracles, while those of the hail, and darkness at crucifixion and the going back of the Sun at the dial of Ahaz, were celestial miracles, the Earth being the recipient of their effects. There was no miracle performed at the dial but in the upper regions of the atmosphere, miles west of the dial, by its refraction of the Sun's light.

The expression "so the Sun returned back," indicates that the miracle was performed just at sunset, and not at sunrise. Every night we see the Sun 34 minutes of arc above the horizon when it is really below it, and would be invisible but for refraction, but this has nothing to do with the miracle: that was produced by an extra and sudden amount of refraction, caused by either a miraculous accumulation of air between the dial and the Sun, or by an increase of the index of refraction, or both.

At sunset the Sun would apparently have to be suddenly elevated but little, to make the shadows of elevated effects like high towers or trees go back (east to west) 10 steps, or calling two feet to equal a step, say about 20 feet which Hezekiah could see from his chamber window, as he was too ill to go to the dial with Isaiah.

LEWIS SWIFT, F. R. A. S.

MARATHON, N. Y., March 3, 1902.

Elementary Calculus.—A new book by Percy F. Smith, Professor of Mathematics in the Sheffield Scientific School of Yale University has been received. The title of the book in full is Elementary Calculus, a text-book for the use of students in general science. The author is right in saying that students who wish to pursue courses of study in science, other than engineering, should study at least the elements of the Calculus. The Sheffield Scientific school of Yale University has recently changed its courses of study in recognition of this demand, and they now include the Calculus.

This little book of 89 pages covers five points: 1. Functions and limits; 2. Differentiation; 3. Applications; 4. Integration, and 5. Partial Derivations. The aim of the book is to give an outline of the subject so that a student may obtain a general knowledge of it for the sake of the elementary applications he may make in the pursuit of scientific studies: The work is greatly condensed. The beginner will need to go slowly and master everything in order to apply its methods successfully. The American Book Company of New York, Cincinnati and Chicago are publishers.

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